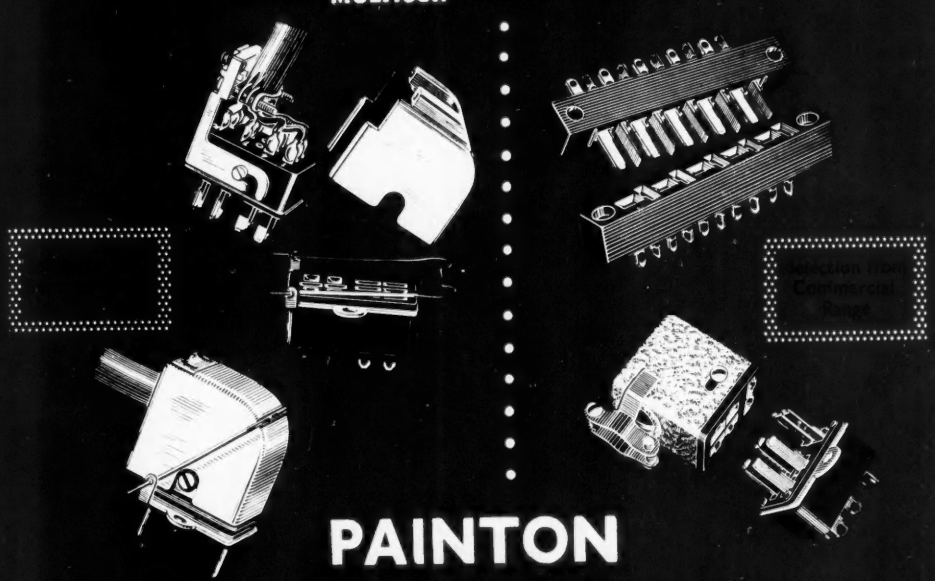
Electronic Engineering

PAINTON

By Appointment to the Professional Engineer

'MULTICON'



PAINTON

DATA for the Designers File

Designers of medium power transmitters will want to know more about the Ediswan ESA.2500.

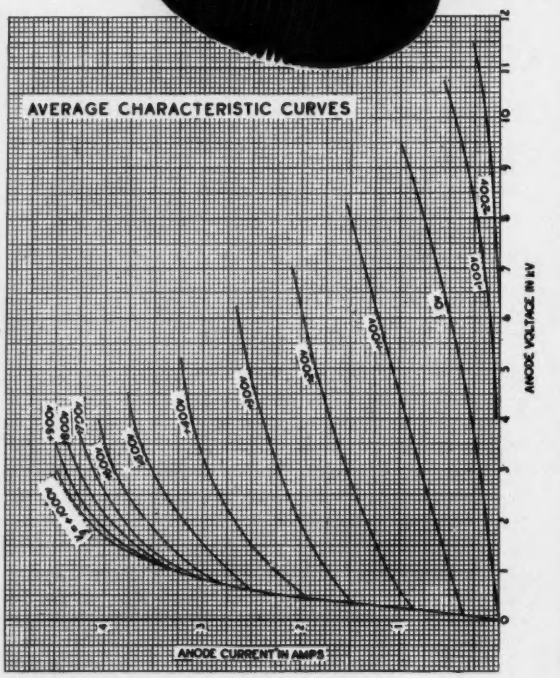
The Ediswan ESA.2500 is a forced air cooled triode designed for use as an R.F. Amplifier or Oscillator. The design of the valve is such that lead inductance is minimised and the valve is, therefore, particularly suitable for H.F. application.

RATING

Filament Voltage (volts)	V_f	8.0
Filament Current (amps)	I_f	80.0
Maximum Anode Voltage (volts)	V_a(max)	7,500
Average Maximum Filament Emission (amps)	Fe_m	4.5
Maximum Anode Dissipation (kW)	W_a(max)	2.5
Mutual Conductance (mA/V)	g_m	* 5.5
Amplification Factor	μ	* 55.0
Anode Impedance (ohms)	r_a	* 10,000
Maximum Operating Frequency at full rating		† 40 Mc/s

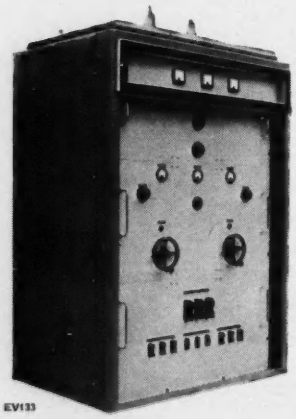
* Taken at V_a=7,000v; I_a=400 mA.

† At higher frequencies the maximum permissible anode voltages and inputs must be reduced.



REDIFON G.41. SHORT WAVE TRANSMITTER USES THE E.S.A. 2500 IN MODULATOR AND OUTPUT STAGES

This medium power short wave Transmitter can be used for Telegraphy, Telephony or Broadcast services in any part of the world. Power output is 5-7-5 kW on Telegraphy. Frequency range 2 to 23 Mc/s.



EV133

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CLASSIFIED ANNOUNCEMENTS

The charge for these advertisements is 6d. per word. Minimum charge 12/-. Box number 2/- extra, except in the case of advertisements for "Situations Wanted," when it is free. Specially spaced advertisements per inch single column 42/6. A remittance must accompany the advertisement. Replies to Box numbers should be addressed to : "Electronic Engineering," 28, Essex Street, Strand, London, W.C.2. Advertisements must be received before the 14th of the month for insertion in the following issue.

OFFICIAL APPOINTMENTS

AIR MINISTRY requires Scientific Officer (male) at R.A.F. Station near Maidenhead, Berks, for operational research duties, theoretical studies and development work in the field of communications and general electronics. Qualifications: First or Second Class Honours degree in physics or electrical engineering, or equivalent. Salary: Within range £467 10s. to £845. Post unestablished with possibilities of establishment through the Civil Service Commission for successful candidate whilst remaining under age 31. Opportunities for promotion to higher grade posts on staff of Scientific Adviser to Air Ministry. Application forms, quoting A 113/5A from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1. Closing date 15 May, 1955. W 3042

AIR MINISTRY require Experimental Officers (min. age 26) at Ruislip, Middlesex, for general experimental duties concerned with radio and radar installations employed in the Royal Air Force. Duties include technical investigations into existing systems, field measurements, design of modifications and development of ancillary equipment. Short periods of duty overseas may be necessary. Qualifications: Minimum of Higher School Certificate (Science) or equivalent, Some experience of communications systems or radar control is essential. Salary within range £735-£900. Application form from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D 112/5A. Closing date 13 May, 1955. W 3043

APPLICATIONS ARE INVITED for pensionable posts as Assistant Examiners in the Patent Office to undertake the official scientific technical and legal work in connexion with Patent Applications. There are a small number of similar posts in the Ministry of Supply. Applications may be accepted up to 31st December, 1955 but early application is advised as an earlier closing date may be announced. Interview Boards will sit at frequent intervals. Candidates must be between 21 and 28 years of age during 1955 (up to 31 for permanent members of Experimental Officer Class) and have First or Second Class Honours degree in physics, chemistry, mechanical or electrical engineering, or mathematics. Candidates taking their degrees in 1955 may apply before the result of their degree examination is known. Starting emoluments in London, including Extra Duty Allowance for 45½-hour week, between £532 and £729 (men) £642 (women) according to periods of National Service and post-graduate experience rising to £896 (men) and £799 (women). Promotion to Examiners: £934 to £1,279 (men), £820 to £1,144 (women); normally after 5 years (3 or 4 years in exceptional cases). Good expectation of promotion to Senior Examiner. Candidates are recruited by selective interview. Application form and further information from the Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting number S 128/55. W 3064

ASSISTANTS (SCIENTIFIC). The Civil Service Commissioners invite applications for pensionable posts. Applications may be accepted up to 31st December, 1955, but early application is advised as an earlier closing date may be announced either for the competition as a whole or in one or more subjects. Interview Boards will sit at frequent intervals. Age at least 17½ and under 26 years of age on 1st January, 1955, with extension for regular service in H.M. Forces, but candidates over 26 with specialized experience may be admitted. Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science or mathematical subject. At least two years' experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces essential in one of the following groups of scientific subjects: (I) Engineering and physical sciences. (II) Chemistry, biochemistry and metallurgy. (III) Biological Sciences. (IV) General (including geology, meteorology, general work ranging over two or more groups (i) to (iii) and highly skilled work in laboratory crafts such as glass-blowing). Inclusive salary scale £262 (at 18) to £545 (men) or £457 (women). Starting pay up to £402 (men) or £357 (women) at 25. Women's pay to be increased under Equal Pay Scheme. Somewhat less in provinces. Opportunities for promotion. Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S 59/55. W 3137

BATTERSEA POLYTECHNIC, London, S.W.11. Applications are invited from graduates of a British University for the following posts:— Senior Lecturer in Telecommunications with good industrial experience. Grade B Lecturer in Electrical Engineering with industrial experience. Salary in each case in accordance with the Burnham Technical Scale for London, less statutory deductions:— Senior Lecturer: £1,101 or £1,113×£25—£1,263. Grade B: £621 or £633×£20—£928 plus £30 for a good Honours degree and an allowance of £18 for 3 years', £36 for 4 years' and £54 for 5 years' training, plus increments for industrial and research experience. Further particulars from the Clerk to the Governing Body, Battersea Polytechnic, London, S.W.11, by whom applications should be received by 7th May, 1955. W 3091

BIRKBECK COLLEGE (University of London). Electronics engineer or Physicist required for the Computational Laboratory to work on problems of Character Recognition in connexion with mechanical Translation. Applicants should have recognized professional qualifications in electronics, and an interest in computing machines. The salary will be in the range of £600-£750 and the appointment will be tenable for three years. Further particulars should be obtained from the Secretary, Birkbeck College, Malet Street, London, W.C.1. Final date for applications Saturday, 28th May, 1955. W 3118

COLLEGE OF TECHNOLOGY, BIRMINGHAM, Department of Physics and Mathematics. Applications are invited for the post of Senior Lecturer in Electronics. Candidates must have high academic qualifications and some research experience, preferably in industry. Teaching experience is desirable but not essential. The successful candidate will be expected to take part in the extensive research programme already in operation. Salary will be in accordance with the Burnham (Further Education) Scale for Senior Lecturers (Men: £1,065×£25—£1,215). Appointment to date from 1st September 1955. Further particulars and form of application may be obtained from the Registrar, College of Technology, Suffolk Street, Birmingham, 1, and completed forms should be returned to him not later than two weeks after the appearance of this advertisement. K. R. Pilling, Clerk to the Governing Body. W 3122

COLLEGE OF TECHNOLOGY, Birmingham, Department of Physics and Mathematics. There is a vacancy for a Research Assistant in the Department of Physics and Mathematics for taking part in a major electronic project. Candidates should have a good honours degree, preferably of London University or of a university which awards higher degrees for external research. Experience in the design of electronic circuits is essential. The successful candidate will be expected to do some teaching, but ample time will be available for research. Salary will be in accordance with the Burnham (Further Education) Scale for Grade "A" Assistants. Basic salary (Men) £510 with increments for approved training and industrial or teaching experience. Further particulars and form of application may be obtained from the Registrar, College of Technology, Suffolk Street, Birmingham, 1, on receipt of a stamped addressed foolscap envelope. Completed forms should be returned not later than two weeks after the appearance of this advertisement. W 3121

COUNTY BOROUGH OF BRIGHTON. Education Committee, Brighton Technical College. Principal: G. E. Watts, M.A., Ph.D. (Cantab), B.Sc.(Lond), F.R.I.C. Required as soon as possible:— Assistant Lecturers in Electrical Engineering (a) Assistant (Grade B), graduate, to teach Electrical Technology, Electronics and/or Telecommunications. (b) Assistant (Grade A) mainly to supervise laboratory and tutorial classes to at least H.N.C. standard and to teach Electrical Technology. Salary scales (men) (a) £525×£25—£820 plus graduate and training allowances; (b) £450×£18—£725 plus training allowance; with increments in both cases for approved research, professional or industrial experience. Further particulars and forms of application may be obtained from the undersigned and should be returned to the Principal, Brighton Technical College, Brighton 7, within 14 days of the appearance of this advertisement. W. G. Stone, Director of Education, 54 Old Steine, Brighton 1. W 3099

D.S.I.R. require an Assistant Experimental Officer at the Radio Research Station, Datchet, Near Windsor, Berks, for abstracting scientific and technical articles on radio research and development. Qualifications in Physics or Electrical Engineering. Minimum: G.C.E. (Advanced Level) in two scientific subjects, or equivalent. Candidates over 22 would normally be expected to have pass degree H.N.C. or equivalent. Some knowledge and experience of radio research or development is necessary and ability to read technical French and German an advantage. Inclusive annual remuneration for a 45½-hour week: Men £297 (age 18)-£659. Women: £297 (age 18)-£556. Application forms from M.L.N.S. Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A 114/5A. Closing date 13 May 1955. W 3063

ELECTRONICS TECHNICIAN, experienced, for interesting and varied work in teaching and research laboratories, salary £610 by £20 to £690, depending on experience and qualifications. Apply Department of Electrical Engineering, University of Birmingham, giving particulars of experience. W 3119

GOVERNMENT OF THE UNION OF SOUTH AFRICA. Division of Civil Aviation: Department of Transport. 1. Applications are invited from suitably qualified persons for appointment on Contract for three years, renewable for a further period, to the Public Service of the Union of South Africa to the posts of: 2. Grading of Posts: (a) Aeradio Mechanic Grade II—Salary scale £360×£30—£630 per annum (temporary minimum £450). (b) Engineer, Grade IV—Salary scale £540×£48—£1,020 per annum. Previous experience will be considered in fixing commencing salary. In addition to the above, married persons will be paid a Cost of Living Allowance of £234 p.a. 3. Minimum qualifications required: In the case of Aeradio Mechanics: Junior Certificate (or equivalent) or five years' apprenticeship or at least five years' appropriate experience. In the case of Engineer, Grade IV: B.Sc. (Electrotechnics) or equivalent. 4. Aeradio Mechanics will be employed on maintenance or radio and radar installations and Engineers Grade IV will be engaged on the planning and installation of navigational and communicational facilities at airports. 5. Conditions of Employment will in the first place be governed by the terms of the Contract and the Public Service Regulations. Successful applicants will be required to acquire within a reasonable time a knowledge of the Afrikaans language. 6. Transport Expenses from place of residence to place of employment (3rd class rail in United Kingdom, tourist, cabin or cheapest 1st class boat to South Africa, whichever is available, and 1st class rail in South Africa) including excess baggage to a maximum of 150 lb. per adult and 75 lb. per child and similar return passage on satisfactory completion of Contract, will be paid by the Union Government. 7. Applications in writing giving full details of qualifications and previous experience should be addressed to Room 102, South Africa House, Trafalgar Square, London, W.C.2, not later than 20th May 1955. W 3068

MADRAS INSTITUTE OF TECHNOLOGY. Applications are invited for the appointment of Professor of Electronics. Candidates should possess good academic qualifications and practical experience. They should be familiar with the latest trends in Electronic Engineering, have

experience in guiding research and preferably technical experience. Contract for 5 years in first instance with prospect of extension. Pay will be determined with reference to qualifications and experience. Free passages. Further particulars and forms of application from High Commission of India, Establishment Department, Aldwych, London, W.C.2, quoting 4/86B. Last date for receipt of applications 21st May, 1955. W 3065

MINISTRY OF SUPPLY requires Electronics Technician at Burghfield, near Reading, to supervise investigation of faults in radar, H.F. and pulse circuits. Qualifications: British of British parents. Recognized engineering apprenticeship or equivalent training in appropriate trade. Detailed knowledge of radar, H.F. and pulse circuitry essential. Experience in fault finding and compiling investigation reports advantageous. H.N.C. or equivalent desirable. Salary: Within £772-£945 p.a. Not established but opportunities to compete for establishment may arise. Application forms from M.L. & N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D150/5A. W 3090

MINISTRY OF TRANSPORT and Civil Aviation require two Engineering Assistants in London for work in connexion with traffic matters. Candidates should be adaptable and have had training in electrical engineering to Higher National Certificate or City and Guilds Diploma standard or equivalent. The work will also require some mathematical and statistical ability. Salary £690 at age 30 or above rising by annual increments to £810 (subject to reduction by one increment of £20 for every year below age 30). Appointments temporary, but opportunities for competing for permanency later are likely. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.21/5A. W 3095

NATIONAL COLLEGE of Horology and Instrument Technology. The Minister of Education, in consultation with the Board of Governors, proposes to fill a vacancy, as from 1st September 1955, for a Head of the National College of Horology and Instrument Technology. The College is accommodated at the Northhampton Polytechnic, St. John Street, London, E.C.1. The College provides for technical education and research to the highest levels in connexion with the horological and the instrument making industries. The curriculum includes a three-year Diploma Course in Horology. Advanced courses in Instrument Technology are projected for next session. Candidates for the post must have good academic qualifications and industrial experience. Salary scale £1,265 by increments of £50 a year to £1,415 p.a. The post is recognized for pension purposes under the Teachers' Superannuation Acts. A letter of application to include particulars of age academic qualifications, industrial experience, and the names of three persons to whom reference may be made, should be sent to the Secretary, National College of Horology and Instrument Technology, Northampton Polytechnic, St. John Street, London, E.C.1. W 3128

SCUNTHORPE HOSPITAL Management Committee Lincolnshire Radiotherapy Centre (52 beds). Vacancy for Medical Physicist in department which is expanding. Work will include developments connected with rotational therapy and the use of radioactive isotopes—candidates should be interested in career in medical physics—previous hospital experience not essential and candidates taking degrees this year will be considered. New entrants to Health Service must serve a probationary period of two years unless any post-graduate study is recognized by Ministry of Health. Salary during probationary period £460 × £25 to £510 for 1st or 2nd Class Honours. Salary after probationary period or to applicants whose post-graduate study is approved by Ministry £585 × £30 to £765. Superannuation Scheme. Applications, naming two referees to Group Secretary, War Memorial Hospital, Scunthorpe, Lincs. W 3138

SENIOR TECHNICIAN required for research work in connexion with high voltage machine for nuclear research. Experience in electronic circuitry and electrical work. Commencing salary in range £490-£590 plus London Weighting. Applications (in writing) as soon as possible to Laboratory Superintendent, Physics Department, Imperial College, London, S.W.7. W 3101

SURREY EDUCATION COMMITTEE, Wimbledon Technical College, Gladstone Road, S.W.19. Required for September, Senior Lecturer in the Electrical Engineering Department. Graduate preferably with research experience, capable of teaching Electronics and Mathematics to post Higher National Certificate level. Salary: Burnham Scale for Senior Lecturers (Men) £1,065×£25—£1,215 p.a., plus London Allowance. Further details from the Principal to whom completed applications should be sent by 14th May. W 3130

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY, Aldermaston, Berks, has the following vacancies:— Post 1 (63/WGE/42) an Experimental Officer to design and develop a wide range of electronic equipment including pulse amplifiers, magnetic amplifiers, high voltage supplies, test equipment using pulse techniques. Some experience of servo systems would be an advantage. Post 2 (585/WGE/42) an Assistant Experimental Officer who has experience or is interested in the development of electrical gauges (e.g., condenser or inductance gauges). The minimum qualification is Higher School Certificate (Science) or equivalent. Salary. Experimental Officer (minimum age 26) £775-£945 p.a. (male). Assistant Experimental Officer £310 (age 18)-£685 p.a. (male). Superannuation. The successful applicants will be required to join the Authority's contributory scheme. Housing. Housing accommodation will be available within a reasonable period for married staff who live outside the radius of the Establishment's transport facilities. During this period lodging allowance may be payable. Send postcard for application form to Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks. Quote appropriate Reference. W 3088

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY, Aldermaston, Berks, requires an Engineer (Basic grade) for engineering of special electronic and light mechanical equipment to meet Scientists' requirements, and progressing to final small scale production. Applicants should have served a recognized engineering apprenticeship and be corporate members of the Institution of Electrical or Mechanical Engineers, or have exempting qualifications. They should have a knowledge of special purpose electronic equipment such as oscilloscopes employing high speed time bases, pulse generators, video amplifiers and stabilized power supply units. Knowledge of the mechanical design problems associated with the manufacture of electronic equipment would be an advantage. Salary: £695 (at age 25) to £1,065 (male) p.a. The successful applicant will be required to join the Authority's contributory superannuation scheme. Housing accommodation will be available within a reasonable period for married staff who live outside the radius of the Establishment's transport facilities. During this period lodging allowance may be payable. Send postcard for application form to Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks. Quote Ref. 565/WGE/42. W 3073

THE UNIVERSITY OF MANCHESTER. Applications are invited from suitably qualified graduates for posts in the Department of Electrical Engineering as Lecturer or Assistant Lecturer. Candidates should have experience in one or more of the following fields. Measurements, D.C. and A.C. Machinery, Servo-Mechanism, High Vacuum technique, Engineering Acoustics, Electronic Circuit technique, Communications. Salary scales per annum: Lecturer £650 to £1,350; Assistant Lecturer, £550 to £650: initial salary and status according to qualifications and experience. Membership of F.S.S.U. and Children's Allowance Scheme. Applications should be sent not later than 21st May 1955, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained. W 3117

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY, Aldermaston, Berks, requires an Electrical Engineer in the grade of Senior Experimental Officer to lead a small team to guide designers in the choice of electronic components. This work involves the development of special components, the testing, specification and forward estimating of component requirements, and the control of a laboratory carrying out prototype testing of components. It also involves close liaison with scientists, engineers and manufacturers, as well as attendance at various Ministry of Supply Committees. The minimum qualification is Higher School Certificate (Science) or equivalent, but a degree in electrical engineering or corporate membership of the I.E.E. is desirable. First-class knowledge and experience of design of commercial electronic components and Type Approval Ministry specifications is essential. Salary: £1,090-£1,285 (male) (minimum age normally 35). The successful applicant will be required to join the Authority's Contributory Superannuation Scheme. Housing accommodation will be available within a reasonable period for married staff who live outside the radius of the Establishment's transport facilities. Send postcard for application form to Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks. Quote reference A301/WGE/42. W 3126

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY, Aldermaston, Berks, requires a Senior Scientific Officer for mathematical work associated with the design and development of radar and electronic devices. Minimum qualification is a First or Second class Honours degree in Mathematics or Physics with a few years' appropriate experience. A knowledge and experience of statistics would be an advantage. Salary: £1,040-£1,205 per annum (male). The successful candidate will be required to join the Authority's contributory superannuation scheme. Housing accommodation will be available within a reasonable period for staff who live outside the radius of the Establishment's transport facilities, or alternatively the Authority may be able to assist the successful candidate in the purchase of a house. An initial period of detached duty may be required to be served at Fort Halstead, Kent. Send postcard for application form to Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks. Quote Ref. 596/WGE/42. W 3127

UNIVERSITY OF SOUTHAMPTON. Research Assistant with an interest in the development of electronic instruments required in the Department of Aeronautical Engineering. The selected candidate (who should be of Degree or H.N.C. standard) will be expected to apply his knowledge to the problems which occur in aerodynamic research and to co-operate directly with aerodynamicists already engaged on such problems. Applications in writing, giving full details of education, qualifications and experience, together with names of two persons to whom reference may be made, to The Secretary and Registrar, before May 31st. W 3135

VACANCIES IN GOVERNMENT SERVICE at Cheltenham. 1. Instrument Makers with fitting and machine shop experience in light engineering. 2. Teleprinter, Radio and Electronic Mechanics and Assembler Testers with experience of telecommunications equipment. Basic Pay—£7 18s. 10d. plus merit pay up to £2 10s. assessed at interview, based on ability and experience. Opportunities for permanent and pensionable posts. Apply in writing only, giving personal particulars to Personnel Officer, G.C.H.W. (Foreign Office), 53 Clarence Street, Cheltenham. W 3029

X-RAY ENGINEER required for responsible senior post in small factory (Edinburgh) undertaking construction, installation and servicing of hospital equipment. Applicant must have extensive experience, and be capable of development and organization of outside work. Starting salary £750 p.a. Box No. W 1327

CLASSIFIED ANNOUNCEMENTS
continued on page 4

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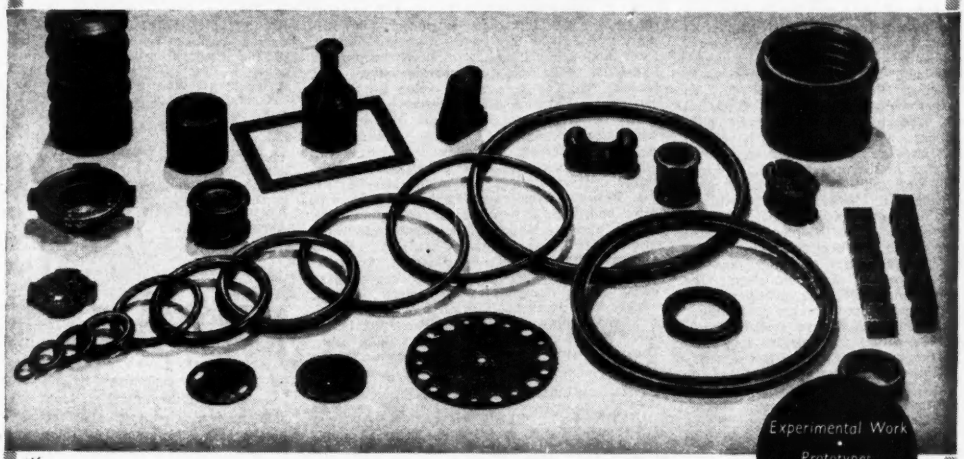

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OFFICIAL APPOINTMENTS (Cont'd.)

UNITED KINGDOM ATOMIC ENERGY AUTHORITY, Atomic Weapons Research Establishment, Aldermaston, Berks, requires Experimental Officers for the following posts: Post 1—287/WGE/42. To assist in the design and development of ultra high speed e'ectronic counting equipment for use with scintillation and other types of radiation detecting instruments. Experience in the design and construction of wide-band electronic amplifiers would be advantageous. Post 2—557/WGE/42. To assist in experimental work in the Chemical Engineering laboratory, mainly with pilot scale equipment. Applicants should have had a chemical engineering training and some years' experience in the operation and development of pilot and small scale plants. The minimum qualification is Higher School Certificate in Science subjects or equivalent, but a Higher National Certificate in applied physics for Post 1 and a pass degree in chemical engineering for Post 2, is desirable. Salary (minimum age 26) £775-£945 p.a. (male). Superannuation. The successful applicants will be required to join the Authority's contributory scheme. Housing. Housing accommodation will be available within a reasonable period for married staff who live outside the radius of the Establishment's transport facilities. During this period lodging allowance may be payable. Send postcard for application form to Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks. Quote appropriate reference. W 3074

UNITED KINGDOM ATOMIC ENERGY AUTHORITY, Aldermaston, invites applications for a Technician to be responsible, with assistance from technical and industrial staff, for performance, climatic and durability tests on electronic and electro-mechanical equipment under development for Service use. Also to be responsible for the maintenance of the plant and equipment used in these tests. Candidates should have served a recognized engineering apprenticeship or have had suitable equivalent training in electrical engineering. Experience of tests and measurements on electrical circuit components is essential and a working knowledge of refrigeration plant, temperature and humidity chambers, vibration test machines, etc. would be advantageous, as would possession of O.N.C. or City and Guilds certificates in appropriate subjects. Candidates should be familiar with Service specifications commonly in use in the class of work concerned. Salary: £710 (linked to age 30) to £830 (male). Successful candidate will be required to join the Authority's Contributory superannuation scheme. Housing will be available within a reasonable period for the selected candidate if married and living outside the radius of the Establishment's transport facilities. During this period, lodging allowance may be payable. An initial period of detached duty may have to be served at Fort Halstead, near Sevenoaks, Kent. Send postcard for application form to: Senior Recruitment Officer, A.W.R.E., Aldermaston, Berks. Quote Ref.: 587/WGE/42. W 3075

SITUATIONS VACANT

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

A GRADUATE PHYSICIST is required to work on the measurement of the fundamental properties of a wide range of semi-conductor materials. The work involves the development of original methods and equipment. Previous experience in the field would be advantageous, but is not essential. Box No. W 2921.

A. H. HUNT (CAPACITORS) LIMITED require engineers for design and development of paper, mica and ceramic capacitors. Applicants should have previous training in electrical engineering at least to intermediate B.Sc. standard. Apply Personnel Manager, A. H. Hunt (Capacitors) Limited, Bendon Valley, Garratt Lane, Wandsworth, S.W.18. W 212

A BRILLIANT FUTURE for young men with original ideas. Are you grasping your opportunities as an Electronic Engineer? The successful Solartron Electronic Group offers a fresh and stimulating atmosphere, encourages individual responsibility, provides the right services. Add to your future value by gaining experience on important commercial applications of the latest electronic and electro-mechanical techniques. Excellent openings for: A Senior Research Engineer to carry out advanced circuit design for all aspects of electronic instrumentation. Minimum salary £1,100 p.a. Project Development Engineers. Men with drive and some experience of production techniques who are skilled in developing electronic instruments from outline circuitry. Salary approx. £800 p.a. Junior Research Assistant. Graduate with sound theoretical background to assist with research; work offers interest, variety and excellent prospects. Salary approx. £550 p a. Apply in writing to Personnel Director, The Solartron Electronic Group Ltd., Queens Road, Thames Ditton, quoting ref.: D.1. W 3123

AIRCRAFT ELECTRICAL DESIGN DRAUGHTSMEN required. Excellent opportunities for advancement. Apply Personnel Department, Vickers-Armstrongs Ltd., Hurslev Park, Nr. Winchester. W 2849

AIRCRAFT RADIO AERIALS. Gloster Aircraft Co. Ltd., Gloucester, have a vacancy for an Electronic Engineer (H.N.C. or equivalent) to work on the development of suppressed aerials for aircraft. The work involves theoretical and practical knowledge of measurements from "H.F." to "X" bands and of the properties of different types of suppressed aerials. A small laboratory is being established for the work. An elementary knowledge of aircraft design and construction would be an advantage. Applications stating age, previous employers and experience, etc. should be addressed to the Employment Officer. W 1319

A LEADING RADIO and Television Manufacturing Company requires the services of a Chief Engineer. Salary up to £3,000 per annum, according to qualifications and experience. Superannuation and Insurance Schemes in operation. Please reply, in strictest confidence, giving full details to Box No. W 3030.

A MAJOR INTERNATIONAL COMPANY in the Electrical Engineering and Electronic field with Headquarters in London will shortly appoint a young Engineering Graduate to train in a Technical/Commercial department of the Television and Radio Division with the object of eventually rising to executive status in charge of a product group. Candidates should be between 25/35 with an Engineering degree and an aptitude for a commercial career. Applications which shall remain confidential should be addressed to Box W 3072.

AN ELECTRONIC ENGINEER is required to initiate and supervise design and development work in a small company concerned with electronic and magnetic devices. A good qualification is desirable but special knowledge is not so important as the ability to analyse problems and control technical staff. Starting salary in the range of £750/£1,200 per annum. Nottingham area. Box No. W 1329.

AN ELECTRONIC OR ELECTRICAL ENGINEER, between the ages of 25 and 35 years, of degree standard, is required to take charge of the engineering department of a factory engaged in the manufacture of frequency control equipment. The successful applicant will be responsible for the design and specification of all new items, as well as routine engineering problems. The position offers a wide scope for a person possessing the necessary technical qualifications and initiative to expand the work along numerous channels. Living accommodation can be made available to the successful applicant. Apply in writing to the Personnel Manager, Standard Telephones and Cables Limited, Crystal Factory, Harlow, Essex. W 3048

AN ELECTRONIC or electrical engineer of degree standard is required to take charge of the Engineering Department in a factory which is part of a large organization engaged in the manufacture of all branches of communications equipment. The successful applicant will be responsible for engineering development, design, and specification of all new items, as well as routine engineering problems. The wide field of work to be covered offers considerable opportunity for advancement. Living accommodation for single or married persons can be made available. Box W. R2419, A.K. Advertising, 212a Shaftesbury Avenue, London, W.C.2. W 3067

APPLICANTS ARE INVITED FROM ELECTRONIC ENGINEERS for the post of Assistant to the Chief Engineer of a progressive organization well established in the field of industrial electronics. Candidates should have a sound theoretical training and considerable practical experience. The factory is located in the Home Counties and there is a pension scheme. Box No. W 3059.

APPLICATIONS ARE INVITED from Senior Project Engineers with a specialized knowledge of the manufacture of Electrical and Mechanical products. Applicants should have a good practical engineering background and a sound technical experience of Tool Design and Planning and be capable of putting new projects on a sound production basis. These vacancies offer excellent opportunities to men seeking permanent and progressive positions. London Area. Applications which will be treated in confidence, should give full details of experience and salary required and be addressed to Box No. W 3103.

APPLICATIONS are invited for the post of Electronics Technician for the Department of Clinical Research. The work of the successful candidate will be devoted largely to the building and reconstruction of electronic equipment in the Department of Electroencephalography. No previous experience of electroencephalographic recording will be required but there will be some opportunities for acquiring it. The appointment will be on a temporary basis and for an initial period of one year, but will be subject to renewal. The salary will be on the scale £500-£620 and an additional £25 p a. will be paid for experience in electronic techniques. Application to be addressed to the Medical Superintendent, Graylingwell Hospital, Chichester. W 3092

APPLICATIONS ARE INVITED from qualified engineers for a number of posts in the Research Laboratories at Cheltenham of S. Smith & Sons (England) Ltd. The posts are permanent and a pension scheme with life insurance is in operation. Housing accommodation is guaranteed to selected applicants after a satisfactory probationary period. The work of the laboratories is mainly, but not wholly, in the aviation instrument field, and applicants should preferably have experience in one or more of the following subjects: (a) Mathematical Study of Controlled stability. (b) Aircraft Navigation and Flight Instruments. (c) Automatic Pilots. (d) Electronics (preferably including knowledge of Magnetic and Transistor Amplifier techniques). (e) Electronic and/or Hydraulic Servo Mechanisms. (f) Aerodynamics. Salaries are in the range of £500 to £1 500 per annum, according to age, ability and experience. Travelling expenses will be

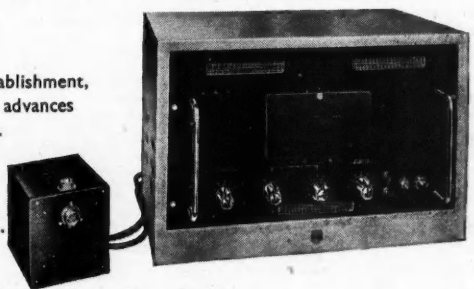
CLASSIFIED ANNOUNCEMENTS
continued on page 6

"... a minimum rise time of 0.08 Microseconds..."

As every schoolmaster knows, pupils are from time to time capable of the most learned dissertations on subjects completely outside the matter in hand. Not, it should be added, that these often concern such specialised subjects as Linear Amplifiers. To be put fully in the picture on this it is necessary to talk to EKCO, who have all the relevant details at their finger-tips.

LINEAR AMPLIFIER TYPE N568.

Developed in conjunction with the Atomic Energy Research Establishment, this highly stabilised wide-band amplifier incorporates the latest advances in the design of linear pulse amplifiers for use in nuclear physics. It comprises a main amplifier; H.F. head amplifier; and cathode-follower head amplifier for use with particle counters working in the proportional region. A maximum overall voltage gain of 1,000,000 is provided and gain stability is of the order of 0.1%.



Please write for illustrated catalogue of the complete range of Ekco electronic equipment for the radiochemical laboratory.

EKCO electronics

EKCO ELECTRONICS LTD. • EKCO WORKS • SOUTHEND-ON-SEA • ESSEX

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 *inclusive or a woman aged* 18-59 *inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order,* 1952.

paid to applicants selected for interview. Write for application form to Personnel Manager, S. Smith & Sons (England) Ltd., Bishops Cleeve, near Cheltenham, quoting Ref. CHR.12/D. W 3044

A SENIOR COMMUNICATIONS ENGINEER is required for responsible post on design of Carrier Telephony Radio Links. Applicants should have a good engineering or science Degree, or equivalent qualifications and at least five years' experience in a similar post. Applications should be addressed to Personnel Department, S.C.E., Murphy Radio Ltd., Welwyn Garden City. W 3014

A SENIOR ENGINEER is required for a responsible post on design of Communications Receivers and Low Power V.H.F. R/T Equipment. Applicants should have a good engineering or science degree, or equivalent qualifications and at least five years' experience in these fields in responsible positions. Applications should be addressed to Personnel Department, S.E., Murphy Radio Limited, Welwyn Garden City. W 3013

ASSISTANT TO THE CHIEF ENGINEER required by an established instrument company in the Home Counties, now pioneering new developments in the field of electronic technology. While academic qualifications are not essential, applicants should have a sound theoretical training and considerable practical experience. The salary will be according to experience—£1,200 per annum is envisaged. There is a pension scheme. Box No. W 2848.

ASSISTANT CHIEF DRAUGHTSMAN required by well-known electronic engineering Company (London area) with large Drawing Office. Applicants, who must be of British Nationality, and have had substantial industrial experience, should be accustomed to working at senior level and posses a first-class personality. Applications will be considered from those who are at present holding an Assistant Chief or Senior position but seek greater scope for their abilities. The position carries a substantial starting salary and a Pension Scheme is in operation. Please write stating age and experience to Box E.E. 203, c/o 191 Gresham House, E.C.2. W 3058

AUTOMATION ENGINEERS required for a new Development Section. Vacancies exist for: 1. Project Engineer, responsible to the Section Head for engineering from the mock up stage and liaison with customers., Ministries, subcontractors and own development sections. Electrical Engineering apprenticeship with electronic experience and A.M.I.E.E. or H.N.C. preferred. 2. Electronic Development Engineer with previous laboratory experience in photo-electrics and servo-mechanisms. O.N.C. or equivalent. 3. Design Draughtsman with electro-mechanical experience. Good prospects, salaries commensurate with qualifications and experience. Apply Personnel Manager, Electronics Division, Hilger & Watts Ltd., 48 Addington Square, London, S.E.5. W 2995

A VACANCY exists for an Electronic Instrument Development Engineer in the Telecommunications Laboratory of British Insulated Callender's Cables Ltd., at Kirkby, near Liverpool. Candidates should hold a degree in Physics or Engineering and have previous experience in the design and development of Electronic Instruments. Applications quoting reference P/60/54 should be addressed to: The Staff Officer, B.I.C.C. Ltd., Prescot, Lancs. W 3125

BTH RESEARCH LABORATORY requires engineers with a Degree or national certificate in electrical engineering who are interested in light current or radio, for testing high power microwave valves, and for the design construction, and maintenance of electrical pulse test equipment, including modulators, cathode ray oscillographs and automatic control circuits. The work in any one of these fields is varied and interesting, and will be carried out in co-operation with a team engaged in research on microwave valves. Application should be made to the Director of Research, British Thomsoon-Houston Co. Ltd., Rugby, quoting reference DR3, and giving age, qualifications and experience. W 2974

A VACANCY OCCURS for a Development Engineer in a Design Group concerned with a wide range of small transformers and inductors of types used in Radio equipment and Electrical appliances. Preference will be given to applicants having experience of this class of work, but young engineers with a sound basic training and limited experience will be considered, and if successful will have the opportunity of gaining practical knowledge of design problems met in fulfilling commercial and military specifications. An attractive salary is offered together with good future prospects. The Company's extensive Laboratory and Production facilities are situated in the London area. Please reply, giving details of qualifications and experience to Box No. W 3089.

BTH RESEARCH LABORATORY requires honours graduates in physics or electrical engineering to join a section engaged in the development of microwave electronic valves. The vacancies are in a group whose primary function is to investigate the fundamental operating mechanisms of established devices such as magnetrons and klystrons and to evolve new types of microwave oscillator. Successful applicants will be required to show initiative and ability to a standard corresponding to work leading to a post graduate degree; they will work in a new laboratory, exceptionally well equipped, and provided with adequate constructional and general engineering facilities. Applications should be made to the Director of Research, British Thomson-Houston Co. Ltd., Rugby, quoting Ref. DR2 and giving age, qualifications and experience. W 2975

BUSH RADIO LTD. require Senior and Junior Engineers in their Laboratories at Chiswick, Kew and Plymouth. Applicants should preferably hold a Higher National Certificate, B.Sc. Engineering or Physics or equivalent qualifications. Experience in the following fields of development would be an advantage:— Domestic Radio or Television, Electronic Equipment for Aircraft, Communication Receivers, Pulse Circuits and Micro-Wave Techniques. Write giving full details and salary required to the Chief Engineer, Power Road, Chiswick, W.4. W 2955

CANADA NEEDS ELECTRONIC ENGINEERS. Measurement Engineering Ltd., with expanding business in Electronic Instrument field, offer generous salary, excellent prospects, to keen man capable of starting and taking charge of a section to handle Magnetic Amplifier Design. Applicants must be Physics or Engineering graduates with several years' industrial experience, including two years on magnetic amplifiers. The location is Ontario, within easy reach of Chalk River and Ottawa. Interviews London (England). Box No. W 1286.

CIRCUIT ENGINEERS required for research work on Colour Television systems especially receiver display devices. 1. Senior Engineers. Must have had a number of years' experience of actual design work on electronic circuits but not necessarily for television. Academic qualification to Degree standard preferred. Men of inventive character capable of making their ideas work are required. 2. Assistants to the above Senior men. Some experience of circuit work and at least H.N.C. or the equivalent essential. Salaries in line with present-day standards. Pension and Life Assurance Scheme. Apply giving age, qualifications and experience to: Sylvania-Thorn Colour Television Labs. Ltd., Great Cambridge Road, Enfield, Middlesex, marked attention: B. C. Fleming-Williams. W 3098

COMMUNICATION ENGINEERS AND DRAUGHTSMEN. The expanding programme of the Transmission Department offers vacancies in both senior and junior categories for Line Transmission Laboratory Engineers and Apparatus Design Engineers, and also for Draughtsmen with experience in telecommunications or light current engineering. Specialist experience in any branch of line transmission engineering is desirable for some of the posts. Positions offered are on the company staff, with contributory pension fund and usual staff conditions. Applicants should write to Personnel Manager, Automatic Telephone & Electric Co. Ltd., Strowger Works, Edge Lane, Liverpool 7, giving full details of age, qualifications and experience. W 2963

DECCA RADAR LIMITED plan in the near future to put a new project on to the market and seek a first-class production engineering designer (preferably with both electronic and mechanical experience) to take charge of the project. Substantial salary on a rising scale. British Nationality essential. There is a Pension Scheme in operation. Reply quoting reference RLA 90 to Decca Radar Limited, Radar Research Laboratory, 2 Tolworth Rise, Surbiton, Surrey. W 216

DECCA RADAR LIMITED invite applications from young men, preferably of H.N.C standard or above, who would like to become microwave engineers working in the modern wide field of navigational aids. Training will be given to suitable applicants to fit them for a progressive career. British Nationality essential. There is a Pension Scheme in operation. Write giving full personal particulars and quoting RLA 91 to Decca Radar Limited, Radar Research Laboratory, 2 Tolworth Rise, Surbiton, Surrey. W 217

DECCA RADAR LIMITED require the services of a first-class mechanical engineer for work on their Microwave Link Systems. This post is a special appointment and a substantial starting salary is envisaged on a rising scale. British Nationality essential. Pension Scheme in operation. Please write giving full particulars and quoting RLA 89 to the Research Director, Decca Radar Ltd., Radar Research Laboratory, 2 Tolworth Rise, Surbiton, Surrey. W 218

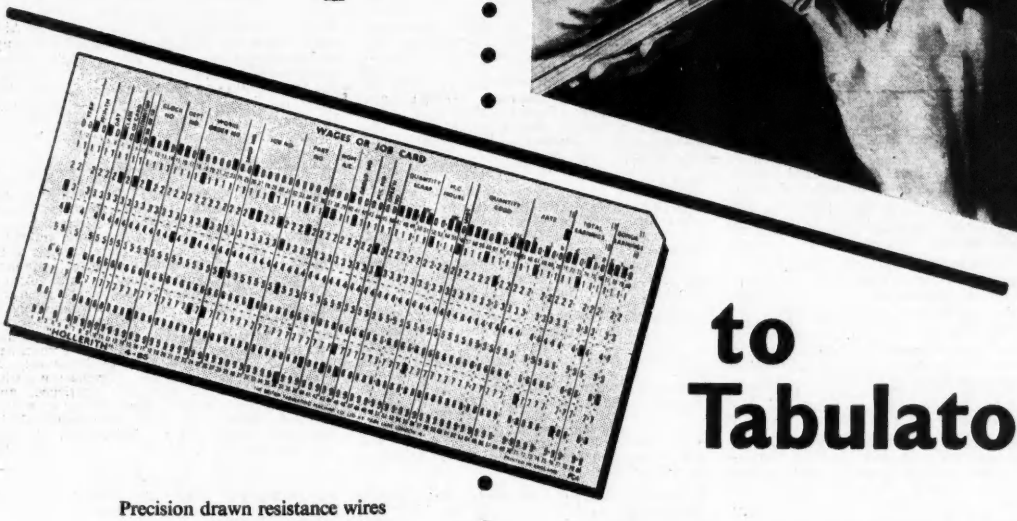
DESIGN AND DEVELOPMENT ENGINEERS. Applications are invited from the following to undertake important work on a wide range of interesting problems in connexion with Guided Weapons Research and Development:— Servo Research Engineer (Ref. E.E./8), To work on electro-pneumatic and hydraulic servo-mechanisms. Degree or H.N.C. essential. Instrument Research Engineers (Ref. E.E./7). To work on Gyroscopic instruments and accelerometers with associated pick-offs. Degree or H.N.C. essential. Electronic Engineers (Ref. E.E./10). To carry out work, associated with the above, on electronic circuitry of magnetic amplifiers. Degree or H.N.C. essential. Graduate Engineers or Physicists (Ref. E.E./9). To solve problems on analogue computors. Previous experience desirable. Degree, electronic experience and a mathematical leaning essential. Good salary and bonus. Pension scheme incorporating Life Assurance. 38 hour, 5-day week. Apply, quoting appropriate reference above, to the Assistant Manager, The Fairey Aviation Co. Ltd., Weapon Division, Heston Aerodrome, Hounslow, Middlesex. W 3069

DESIGN DRAUGHTSMAN is offered opportunity of entering an expanding department dealing with Specialized Automatic Production Equipment for the Engineering Industries. Ingenuity and/or experience in Mechanized Work Transfer and Jigging are desirable qualifications for progressive position with good pay and conditions. Apply in writing, with details of age, education, experience, to Personnel Officer (I.H.D.) Birlec Limited, Tyburn Road, Birmingham, 24. W 3107

DESIGN ENGINEERS & DRAUGHTSMEN are required by Kelvin & Hughes Limited, at their Barkingside, Essex, works for electro-mechanical instrument development work. Recent design experience in a similar, or associated field is required, together with a technical background, preferably of at least Higher National Certificate standard. Applicants should also have had a mechanical engineering apprenticeship, or equivalent practical training, and possession of some knowledge of Electronics is an advantage. The positions are permanent and offer scope within an expanding Organization to designers of progressive outlook who are able to use their own initiative. Written application, in strictest confidence, should be addressed to the Personnel Manager, Kelvin & Hughes, Ltd., New North Road, Barkingside, Essex. W 3086

CLASSIFIED ANNOUNCEMENTS
continued on page 8

From Tally....



to Tabulator

Precision drawn resistance wires
Nickel cathode tubes
Grid support wire
Silver-clad copper and Invar wire
Contacts and contact springs
Waveguide tube
Rhodium electrodeposits
Metallised ceramic bushes
Precision silvered mica capacitor plates
Silvered mica capacitors
Fine fuse wires
Platinum : rhodium-platinum thermocouples
Pallador thermocouples
Mallory 73 Beryllium Copper wire and strip
JMC Phosphor Bronze
Bourdon, capillary and pointer tubes
Hair spring strip
Galvanometer suspension strip
Wires for resistance thermometry
Silver brazing alloys
Precision turned repetition parts

Technical data sheets covering JMC products for electrical, electronic and instrument engineering are available on request.

Increasing mechanisation is closely linked with the development of reliable instrumentation. Both depend on progress in metallurgy—a science fundamental to modern technology. Johnson Matthey products for the instrument industry are based on the Company's century-long experience of specialised metallurgy. Supported by intimate knowledge of requirements this experience has yielded materials and components that contribute substantially to the quality, accuracy and reliability of the wide range of instruments in which they are now used.

Originally developed for speedy accounting, the tabulator is now associated with the latest electronic calculating machines for the analysis of complex scientific computations.

Johnson Matthey

JOHNSON, MATTHEY & CO., LIMITED, HATTON GARDEN, LONDON, E.C.1
Telephone : HOLborn 6989. *Vittoria Street, Birmingham, 1. Tel: Central 8004. 75-79 Eyre Street, Sheffield, 1. Tel: 29212*

I.4

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

DESIGNER-DRAUGHTSMEN required for work on Audio Equipment, to produce manufacturing details from prototype information. Wide variety of work including electro-mechanical devices and casing details. Apply Chief Engineer, Pye Limited, St. Andrew's Road, Cambridge. W 3083

DESIGNER DRAUGHTSMEN with sound experience of Presision Mechanical or Electro-Mechanical Equipment and holding the H.N.C. required on important work in the London area by Large Engineering Company. Salary in £600/£800 year range to successful applicants, together with a living allowance if coming from outside the district. Positions are permanent and Pensionable. Please write giving full particulars of experience and qualifications to Box No. W 1291.

DESIGNS ENGINEER. There is a vacancy for a Designer of Magnetic Recording equipment in the Domestic Electronics Division of E.M.I. A number of interesting projects are in hand giving scope for inventive ability to applicants who have knowledge of electrical circuitry or interest in small mechanisms. Salary will be commensurate with ability and all applications will be seen by the Chief Designer. Write in the first instance giving full details to Personnel Dept., E.M.I. Ltd., Blyth Road, Hayes, Middlesex. W 3082

DEVELOPMENT ENGINEER required for work on transistor amplifiers. Previous experience need not include transistor applications but applicant should be conversant with general radio engineering practice in particular with negative feed back technique, Class "B" amplification and design of detector circuits. Applications to: Personnel Manager (Quote 0960), Ferguson Radio Corp. Ltd., Great Cambridge Road, Enfield, Middlesex. W 3080

DEVELOPMENT ENGINEER required for work on transistor oscillators. Previous experience need not include transistor applications but a fundamental knowledge of time base circuits is desirable. Applications to:— Personnel Manager (Quote A, 12063), Ferguson Radio Corp. Ltd., Great Cambridge Road, Enfield, Middlesex. W 3081

DEVELOPMENT ENGINEER required Radio and Electronics. A small but very progressive and rapidly expanding Company manufacturing relays, switches, small motors and similar products wishes to appoint a Development Engineer to work on the application of its products particularly in the field of radio and electronics. The selected applicant will be required to collaborate with customers' engineers in matters affecting the use of the Company's products and also to assist in the development of new components and applications thereof. The prospects are exceptional and therefore only engineers able to advance rapidly with a new department should consider this advertisement. The qualifications called for are sound technical training and wide experience in electronics, a large measure of initiative and the ability to work smoothly with others. The salary will be in proportion to the high standard of qualification required. A pension scheme is in operation and new housing can be provided. Write giving full details of qualifications and experience, and state salary required to Box No. W 3113.

DEVELOPMENT ENGINEERS. A leading Manufacturer of Radio and Television Receivers has vacancies in its Laboratories for Electronic Engineers with experience in the Design and Development of this type of equipment. Situated in the Midlands. Salaries according to qualifications and experience. Those interested should write, giving details of career and salary expected to the Personnel Manager (Ref. GLB), Box No. W 3037.

DEVELOPMENT ENGINEERS to help design Electronic Instruments. Permanent posts, salary range £550-£750 p.a. according to experience. Taylor Electrical Instruments Ltd., Montrose Avenue, Slough. 'Phone Slough 21381. Write or 'phone for appointment. W 1325

DEVELOPMENT ENGINEERS. Applications are invited from men interested in design work on weighing and recording equipment, embodying electronic and electro-mechanical features, recently marketed by the Company. These are Staff appointments. Salaries commensurate with qualifications and experience. Sick Pay and Pension Schemes are in operation. Write, giving personal particulars, to the Personnel Officer, The British Tabulating Machine Co. Ltd., Letchworth, Herts. W 3054

DEVELOPMENT ENGINEERS. The British Tabulating Machine Co. Ltd., Letchworth, Herts, manufacturers of Electro-mechanical and Electronic punched card accounting and statistical machinery, has vacancies for Graduate Engineers and men of H.N.C. Standard who have completed their National Service, on interesting Electro-Mechanical Design and Development work. Previous shop and design experience preferred. Salary according to experience and qualifications. Pension and Sick Pay Schemes are in operation. Write giving personal particulars to Personnel Officer. (ref. E628E). W 2926

DRAUGHTSMAN REQUIRED by manufacturers of precision sheet metal equipment. Appointment first at Islington then Uxbridge. Experience in product design and jig and tool work an advantage. Excellent prospects. Alfred Imhof Limited, 96a Newington Green Road, Islington, N.1. Canonbury 1281 Ext. 14. W 3087

DRAUGHTSMEN. An expanding production programme has created a number of vacancies for Mechanical Designers, Senior Draughtsmen and Detail Draughtsmen. Situated in the Midlands. The work involves the complete engineering of electronic apparatus for Government Contracts and of domestic Radio and Television equipment. Applicants interested in this type of work, with or without experience, are invited to apply, giving details of career and salary expected to the Personnel Manager. (Ref.GLB) Box No. W 2996.

DRAUGHTSMEN: Vacancies for senior draughtsmen with experience of Electronic and/or Electro-mechanical engineering required, preferably with experience of Ministry requirements. Excellent prospects with good commencing salaries; non-contributory Pension Scheme in operation. Applications will be treated in strict confidence and should give full chronological details of qualifications, experience and age to: John A. Smith Ltd., 24 Lichfield Street, Wolverhampton. W 201

EDISON SWAN ELECTRIC COMPANY LIMITED, have a vacancy for an engineer to take charge of their Special Products' Development Laboratory. Candidates should have an Engineering Degree or its equivalent, and should have experience in developing electronic equipment ready for factory production. Please write full particulars, including age and salary required, to 155 Charing Cross Road, London, W.C.2. Reference K.S.P. W 184

ELECTRICAL AND MECHANICAL ENGINEERS. Sunvic Controls Ltd. (a subsidiary of Metropolitan-Vickers Electrical Co. Ltd.) have the following vacancies in their new Development and Production Units at Harlow. 1. Graduate Engineer with experience in design or development of electro-mechanical mechanisms and their application to instrument problems. 2. Graduate engineer with practical experience in the development of electronic equipment and preferably a knowledge of the latest development in pulse techniques. 3. Application engineer of degree standard with experience in the application of electronic techniques to industrial and process control problems. The above positions are permanent and offer excellent prospects for promotion in a team engaged on the development and manufacture of a wide range of new instruments. Salaries will be according to age and ability. The Company's contributory pension scheme applies in all cases, and housing is available if required. Reply in writing, giving full particulars of age, experience, qualifications and present situation, to Chief Engineer, Sunvic Controls Ltd., Harlow, Essex. W 209

ELECTRICAL ENGINEERS. Graduates required for work associated with Automatic Control Systems. Work includes detailed design of control circuits and co-ordination of schemes. Knowledge of electronic and magnetic amplifier techniques an advantage. Vacancies also for those with specialized knowledge for development work on control systems. The posts are permanent and pensionable. Applicants must have completed or be exempt from National Service. Apply in writing, marking envelope "L1" to Personnel Manager, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17. W 2934

ELECTRICAL / ELECTRONIC / RADIO ENGINEERS. A number of vacancies exist in the Design Organization of Vickers-Armstrongs Limited, Hursley Park, near Winchester. The work will include development, design and testing of latest specialized installations in Aircraft. Applicants with varying qualifications up to Degree standard are invited to apply. Salary commensurate with experience and ability. Recommendation may be made for housing after qualifying period. Apply:— Personnel Department, Vickers-Armstrongs Limited, Hursley Park, near Winchester. W 3129

ELECTRICAL ENGINEERS, Senior and Junior, are urgently required for the Engine Controls Department of Smiths Aircraft Instruments Ltd. at Cheltenham. The work embraces Research and Development on automatic controls for aero gas turbines, magnetic amplifiers and electro mechanical control units. Applicants should have some experience of magnetic amplifiers, electronics, small electro-mechanical instruments or theoretical or practical aspects of servo mechanisms. The positions are permanent and carry generous salaries commensurate with experience and qualifications. A Pension Scheme is available. Applications with full details of qualifications, experience, and salary required, should be made to: Personnel Manager, Smiths Aircraft Instruments Ltd., Bishop's Cleeve, near Cheltenham, quoting reference 51/EN. W 1292

ELECTRONIC DESIGN DRAUGHTSMAN with design experience in Electronic industrial applications, required by West London firm of consultants. Progressive position with good commencing salary. Write giving full particulars of qualifications and experience to Box No. W 1323.

ELECTRONIC ENGINEER required for Senior position in an expanding laboratory engaged on the development of electronic equipment including control gear, servo-mechanisms and special purpose tape recorders. Applicants should state qualifications, experience and salary required. Write for details to Box No. W 1321.

ELECTRONIC ENGINEER required by London manufacturers of Radio Components to take charge of measurements Laboratory and test gear design. Experience of measurement of capacitors or telecommunication cables essential. Salary £750 p.a. Write details of qualifications, experience, age and present salary. Box No. W 186.

ELECTRONIC ENGINEERS required for development work: Experience in pulse circuits desirable: H.N.C. standard. Write (or call) stating age, qualifications, etc., to Personnel Manager, Venner Electronics Limited, Kingston By-Pass, New Malden, Surrey. (MALden 2442.) W 3134

ELECTRONIC ENGINEERS OR PHYSICISTS with electronic backgrounds are required by an instrument firm pioneering new developments in the field of radiation physics. Applicants should be well qualified theoretically and practically, and the post would be of particular interest to those who wish to increase their experience in contemporary electronic problems. The salary range for the post, which is pensionable, will be between £900 and £1,100 per annum, and the factory is situated in pleasant surroundings and can be reached in about 30 minutes by train from Waterloo. Box No. 3060.

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

ELECTRONIC ENGINEER required for maintenance and construction of specialized factory equipment. Final City & Guilds, Higher National or Inter B.Sc. Standard. Age preferably under 35. Reply stating experience and salary: Anglo-Celtic Watch Co., Ltd., Ystradgynlais, Nr. Swansea. W 1331

ELECTRONIC ENGINEERS are wanted in large Midland Engineering Plant, the positions are progressive and interesting requiring qualified and experienced Electronic Engineers, Senior and junior for rapidly expanding laboratory engaged upon measurement and control problems. State age, qualifications and experience fully, in confidence, to Box No. W 3109.

ELECTRONIC ENGINEERS. Experienced Graduates required for work on devices employing television technique and also the design of electrical circuits around transistors. Commencing salary up to £1,500 p.a. for really competent men. Excellent working conditions in new factory in Surrey (½ hour Waterloo). Apply Box No. W 3096.

ELLIOTT BROS. (LONDON) Ltd., servo-components division. The growth of the newly formed Servo-Components Division of Elliott Bros. (London) Ltd., creates openings for the following positions:— (1) A senior engineer to be responsible to the Chief Engineer and to lead a team concerned with the development of electro-mechanical and hydraulic servo-components. Newly built laboratories are being equipped for the investigation of improved system techniques and the design of components to fulfil both Commercial and Service requirements. Applicants must possess an honours degree or equivalent and must have a sound knowledge of servo-systems and the design of components for quantity production. (2) Development engineer to undertake detailed experimental and development work on servo-systems and components. Applicants should possess a good University degree or the equivalent experience. (3) Senior production designer for small precision electromechanical components. This person will be required to take charge of a team of Designers and Draughtsmen engaged on the production design of advanced servo-components. Approximately 5 years' experience in this class of work is necessary and familiarity with modern materials and production techniques is essential. Applications for the above positions giving full particulars of age, education, experience and salary expected to Personnel Officer, Elliott Bros. (London) Ltd., Century Works, Lewisham, S.E.13. W 3116

ENGINEERS AND PHYSICISTS with a Degree or H.N.C. are required for permanent posts in the Guided Weapons Division of The English Electric Company Limited at Luton, for work on analogue computors and simulators. In particular a Senior Man is required to supervise the design and construction of a large general purpose computor, and there are Junior Posts connected with this project and others allied to it. Applicants should preferably have design experience in analogue computing or related fields such as servo-mechanisms and negative feedback systems. Applications to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. S.A.50C. W 2977

ENGINEER with electrical or physicist degree required for development work on testing equipment for telecommunication cables. Permanent and pensionable position at salary commensurate with experience and qualifications. Please apply, giving full particulars to Personnel Officer, Southern United Telephone Cables Ltd., Dagenham Dock, Essex. W 1316

ENGINEER with electrical or physicist Degree required for development work on testing equipment for telecommunication cables. Permanent and pensionable position at salary commensurate with experience and qualifications. please apply giving full particulars to Personnel Officer, Southern United Telephone Cables Ltd., Dagenham Dock, Essex. W 1300

ENGINEERS AND DRAUGHTSMEN: Excellent opportunities for keen and enthusiastic engineers and draughtsmen for a wide variety of work associated with Radio and Machine Frequency, Resistance Heating Development, and Application problems. The posts are permanent and pensionable, and every opportunity for advancement is available. Salary will be in accordance with age, experience and qualifications. Engineers for development and design of Radio Frequency Generators. Applicants must have had a full time electrical apprenticeship and experience in high power R.F. equipment. Qualifications—H.N.C. or full time University Degree. Engineers for development and design of Mechanical Handling Equipment associated with Radio and Machine Frequency Heating Applications. Applicants must have had a full electrical or mechanical apprenticeship and experience in the design of Mechanical Handling Equipment, including pneumatics and hydraulics. Qualifications—H.N.C. or full time University Degree. Technical Assistants and Junior Engineers for Experimental Laboratory work on problems related to the application of Radio, Machine Frequencies, and Resistance Heating. Candidates must have had a full time electrical or mechanical apprenticeship and reached at least O.N.C. standard. Draughtsmen, Seniors and Juniors for circuitry layouts, mechanical and electrical equipment associated with Radio, Machine Frequency, and Resistance Heating Applications. Candidates must have had a full electrical or mechanical apprenticeship and have O.N.C. or H.N.C. in electrical or mechanical engineering. Write for application form to: The Personnel Manager, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, marking envelope "R.I". W 3050

EXPERIENCED Radio Testers and Inspectors required for production of communication and radio apparatus. Also Instrument makers, wirer and assemblers for Factory Test apparatus. Apply Personnel Manager, E. K. Cole Ltd., Ekco Works, Malmesbury, Wilts. W 146

ENGLISH ELECTRIC VALVE CO. LTD., Chelmsford. Junior Engineers required for Valve Development Work, especially on the application of microwave valves to circuitry. Applicants should have a Degree and preferably some experience in microwave technique or alternatively with amateur transmitters. Apply, quoting Ref. 497M. to Dept. C.P.S., 336/7 Strand, W.C.2. W 2976

EXPERIENCED ENGINEERS are invited to apply for a position where energy, initiative and skill will be well rewarded. The work relates to the development of Television Circuits, and the design of components for large scale production. Experience of Television Receiver Design is required in respect to means of scanning and focusing or the design of R.F. and I.F. Circuits. The position is a permanent one which offers scope for advancement to a senior position. The commencing salary will be in accordance with experience, based on a generous and progressive scale. Write, giving full personal particulars to the Personnel Manager, The Plessey Company Ltd., Ilford, Essex. W 3051

ERICSSON TELEPHONES LTD. have in their Research Laboratories a number of vacancies for circuit designers and equipment engineers to work on nucleonic instruments, and interesting new developments in electronic computing and switching; both senior and junior posts are available. Applicants should have a degree or equivalent plus several years' experience of appropriate work for the senior posts; correspondingly reduced qualifications and experience will be accepted for junior posts. Salaries will be in accordance with age, qualifications and experience. Applications, giving details of age, academic or other training and qualifications, experience, and starting salary required, should be sent to the Personnel Officer, Ericsson Telephones Ltd., Beeston, Nottingham. W 197

FERRANTI LTD. (Moston) Manchester, have vacancies for Test Engineers to undertake work under the following headings: 1. General testing and fault finding on electronic and servo units. 2. Advanced testing of above units in final forms as analogue computors. 3. General testing of electronic testing outfits. (This will mainly involve electrical measurements.) 4. General testing and fault finding on gyroscopic instruments. 5. Design, development and maintenance of test equipment for electronics, servos and gyroscopes. Knowledge of general power supplies would be an advantage. A standard of approximately H.N.C. is desirable but lesser qualifications would be acceptable if combined with practical ability and experience of this or analogous work (e.g., in H.M. Forces). Permanent Staff appointments with Pension benefits. Application forms from Mr. T. J. Lunt, Staff Manager, Ferranti Ltd., Hollinwood, Lancs. Please quote reference HGN. W 3035

FERRANTI LTD., (Electronics Dept.) Manchester have the following vacancies at their Moston, Chadderton and Wythenshawe factories:— 1. Chief Planning Engineer for Cathode Ray Tube production. The essential qualification is previous responsibility and experience in planning and progress, preferably, though not necessarily, in C.R.T. manufacture. 2. Process Control Engineers with considerable experience of C.R.T. production and of the technical problems involved. 3. Technical Maintenance Engineer with experience of vacuum equipment and automatic and mechanical apparatus of the type used in C.R.T. production. Knowledge of electronic circuitry would be an advantage. 4. Plant Engineer. A young mechanical engineer, preferably with some knowledge of vacuum or chemical techniques is required to assist in the design of automatic plant for C.R.T. and valve production. 5. Circuit Engineer for work with new types of valves including the design of circuitry for use with them. The successful candidate would also assist the Sales Department in establishing these new types. 6. Valve Design Engineers holding good Honours Degrees in Physics or Electrical Engineering and preferably with previous experience of Valve design. 7. Circuit Engineer for a Ceramic Valve Laboratory, having experience of R.F. work and preferably of pulse circuitry. He would be required to determine the characteristics of advanced types of valves opening up new and interesting fields. Salaries would depend on age and experience within the following ranges:— Post 1—£800-£1.000 per annum. Posts 2, 4, 5, 6, and 7—£600-£900 per annum. Post 3—£500-£700 per annum. Permanent staff appointments with Pension benefits. Application forms from Mr. T. J. Lunt, Staff Manager, Ferranti Ltd., Hollinwood, Lancs. Please quote reference PDH 1, 2, 3, 4, 5, 6, or 7. W 2984

FERGUSON RADIO CORPORATION Ltd., have a vacancy for an Engineer with initiative and a sound technical background to take charge of a small, well equipped test gear Laboratory situated at Spennymoor, Co. Durham. The post is permanent for a man with previous similar experience and able to carry responsibility in a rapidly expanding department and offers exceptional promotion and long term prospects. The successful applicant will be eligible for the Company's pension and life

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

assurance scheme. Applications in writing giving full particulars as to age, qualifications and experience to: Personnel Manager (Quote 0979), Ferguson Radio Corporation Ltd., Great Cambridge Road, Enfield, Middlesex. W 3120

FERRANTI LIMITED, Edinburgh have vacancies for additional Junior and Senior Draughtsmen who are suitably qualified and interested in the design of (a) Instruments, (b) Light Precision Mechanisms, (c) Electronic Equipment and (d) Machine Tools. Experience in any of the above headings is an advantage, but not essential for these vacancies. Apply quoting Ref. 23/D.D.O. and give full details of training and experience in chronological order to the Personnel Officer, Ferranti Limited, Ferry Road, Edinburgh, 5. W 3124

FIRST-CLASS DESIGN DRAUGHTSMEN required for high production press tools, jigs, fixtures, etc., for valve and cathode ray tube components. Background of practical experience and O.N.C. least qualifications, but H.N.C. preferred. Experience in the use of tungsten carbide an advantage. Rates substantially above normal minimum for men of suitable experience. Five-day week, staff pension scheme, modern welfare amenities. Apply Personnel Superintendent, The Edison Swan Electric Co. Ltd., Cosmos Works, Brimsdown, Enfield, Middlesex. W 3061

GENERAL MANAGER required by a light engineering group of companies to operate an electrical instrument manufacturing business in Southern England which has a full order book, excellent equipment and very substantial development prospects. The successful applicant will be a man with a wide understanding of and technical imagination in the weak current field. He must be a factory trained man with knowledge of management practices and the problems of the precision light engineering industry, whilst these qualities must be combined with a flair for business. The post carries a generous salary commensurate with the experience and substance of the selected candidate, and is pensionable. Applications will be treated in strict confidence and should be made with details of age, qualifications and career to date to Box E.E.283 c/o 191 Gresham House, E.C.2. W 3141

GUIDED WEAPONS: Design Engineers—Technicians. The Guided Weapons Department of the Bristol Aeroplane Company Limited, at Filton, requires to recruit the following:— 1. Design Engineer: to design and develop D.C. and L.F. circuitry for use in computing and other servo applications. A Degree in electrical Engineering or an equivalent professional qualification is desirable. 2. Technical Assistant: To service electronic-servo test equipment. Considerable practical experience, a high standard of education and a sense of responsibility are essential requirements. Applications, quoting D.O.35, giving details of age, experience, and salary required, should be addressed to the Personnel Manager, Aircraft Division, Bristol Aeroplane Company Limited, Filton House, Bristol. W 2986

GYRO DEVELOPMENT ENGINEERS required with first-hand knowledge of development work in small gyroscopes. These vacancies fall into two categories:— (1) Mechanical development engineer used to handling precision bearings, balancing machines, etc.; (2) Electro-mechanical engineers with knowledge of A.C. and D.C. torque motors, voltage pick-offs and gyro motors. Write in detail or send postcard for form of Application, quoting Ref. 143 (1) or (2) to: The Personnel Manager (Technical Employment), de Havilland Propellers Ltd., Hatfield, Herts. W 3100

HONOURS GRADUATE in physics or electrical engineering is required to work in a laboratory engaged in research and development on frequency control problems relating to communication systems. The position is open to men and women and affords excellent opportunities for detailed study of the theoretical and practical aspects of the subject. Living accommodation for single or married persons can be made available. Box W. R2423, A.K. Advg., 212a Shaftesbury Ave., London, W.C.2. W 3066

HATFIELD INSTRUMENTS LTD., who are now expanding their laboratories require senior and junior electronic engineers with experience in the design and test of high grade Radio and Industrial Laboratory Equipment. Apply in writing in the first instance stating age, experience and salary required to Hatfield Instruments Ltd., 175 Uxbridge Road, Hanwell, W.7. W 3038

HIVAC LIMITED, Manufacturers of specialized thermionic and electronic devices, offer interesting posts for scientists, engineers and technicians in their existing organization on research and development projects in valves, cold cathode tubes and transistors. Previous experience in these fields, though an advantage, is not essential, but a sound education and an active and inquiring mind are. Encouragement will be given, wherever possible, to the publication of original work. The Company is a member of a major communications Group and the posts, which are available for both senior and junior applicants, are pensionable and offer scope for advancement. There is a five-day working week. Applications in writing, which will be treated in strict confidence, stating age, education, qualifications and salary expected, should be addressed to The Engineer-in-Chief, Hivac Limited, Greenhill Crescent, Harrow, Middlesex. W 3025

HONOURS GRADUATES in Physics or Electrical Engineering are required for advanced work in a Quartz Crystal Laboratory. The positions offered afford excellent opportunities for young men or women to specialize in the study of piezoelectric materials from both the theoretical and practical viewpoints. An interest in mathematics and electronics would be an advantage for this work. Living accommodation can be made available to successful applicants. Write Box W. Q9365, A. K. Advg., 212a Shaftesbury Avenue, London, W.C.2. W 3041

INTEGRAL LIMITED, Birmingham Road, Wolverhampton invite applications for the position of Senior Engineer able to undertake design and development work in connexion with Electronic and pulse equipment. This is a responsible position and applicants should have had at least five years' similar experience. Applications to Personnel Manager, stating age, qualifications, experience and salary required. W 1324

INTERMEDIATE & SENIOR DRAUGHTSMEN (24-30) required for Production Drawing Office. Applicants should have good mechanical background, together with some electronic knowledge. O.N.C. standard preferred. Applications in writing may be made in the strictest confidence to Personnel Manager, Kelvin & Hughes Ltd., New North Road, Barkingside, Ilford, Essex. W 3078

JUNIOR ENGINEERS required to assist in systems planning of Facsimile and other electronic telegraph equipment. The work requires a standard equivalent to H.N. Cert., but applicants who are less advanced and are continuing their studies will be given full consideration. Previous experience in Telecommunications an advantage but not necessarily essential. The positions are permanent and pensionable and applicants who have completed or are exempt from National Service are invited to apply by letter to the Personnel Manager, Creed & Co. Ltd., East Croydon, Surrey, giving qualifications and any other information they consider will enable us to assess their suitability. W 3045

LARGE COMPANY seeks man to initiate application of electronics to the control of mass-production processes. Must be able to work on own initiative and will be given facilities for developing new devices as well as advising on the application of available electronic equipment. Applications to Ref: PEC/1 Box 3W, Q 9371, A. K. Advg. 212a Shaftesbury Avenue, W.C.2. W 3040

MAINTENANCE OF MULTI CHANNEL DEMONSTRATION LINKS. Two Engineers, with suitable radio experience, required for the maintenance of the above. Apply, to the Personnel Manager, Pye Telecommunications Ltd., Ditton Works, Cambridge. W 3085

MANAGER REQUIRED for unit of a well-established Engineering Company engaged in large scale production of Radio and Television. The successful candidate will have a specialized knowledge of this class of work and will be capable of advising and supervising the Design Laboratories, Tool Design, Planning, and Machine and Assembly departments. This vacancy offers ample scope and opportunity to a man with high administrative ability. Salary up to £2,500 per annum. London Area. Please reply, in confidence, giving full details to Box No. W 3102.

METROPOLITAN-VICKERS ELECTRICAL CO. LTD., Trafford Park, Manchester 17, have vacancies for servo engineers with some practical experience in Electric servo and control circuit design and application. Qualifications required, a Degree or Higher National Certificate. Applicants should not be less than 26 years of age. The posts are permanent and pensionable. Salary according to qualifications and experience. Apply in writing to The Personnel Manager, marking envelope "Servo Mechanisms." W 2557

McMICHAEL RADIO LTD., Slough, Bucks, have vacancies from time to time for Electronic Engineers to be engaged on Government projects. Those wishing to be considered are invited to write fully to the Chief Engineer, Equipment Division. W 205

MONSANTO CHEMICALS LIMITED invite applications for a post in research at Ruabon on Instrument Development work. Candidates should preferably be 23-28 years of age with an Honours Degree or equivalent in Physics or Electrical Engineering. A knowledge of Chemistry up to Higher National or Pass Degree would be an added advantage although not essential. The post, which offers good scope and prospects, is permanent and pensionable and is concerned with the development of new instruments both for Physical and Chemical research and for Chemical Production usage. A salary fully commensurate with experience and qualifications is offered. Details in writing of age, education, training and experience should be sent to The Chief Personnel Officer, Monsanto Chemicals Limited, 8 Waterloo Place, London, S.W.1. W 3111

MURPHY RADIO LIMITED have vacancies in the Electronics Division Laboratories for qualified engineers to design and develop the following:— 1. V.H.F. and U.H.F. Communications equipment. 2. Airborne and Ground radar equipment. 3. Computing devices and servo systems. 4. Nucleonic equipment and measuring instruments. 5. Transistors. The salary range is £600—£1,000 per annum depending upon experience. Further posts are available to engineers of H.N.C. standard or equivalent having less experience, the salary range being £450—£650 per annum. These vacancies are at Welwyn Garden City but one or two vacancies of a similar nature are available at the Ruislip Works. Applications, giving age, full details of qualifications, experience and salary required, should be forwarded to Personnel Department, Murphy Radio Ltd., Welwyn Garden City. W 3015

MULLARD RESEARCH LABORATORIES in Surrey have a number of vacancies for Physicists and Electronic Engineers with a good Degree or equivalent qualification for work in a variety of projects including: (1) Solid Physics and Semi-Conductors. (2) Magnetic Materials and applications. (3) Microwave techniques. (4) Advanced Electronic circuit techniques, including Transistor applications. (5) Colour Television. (6) Computers and Servo-Mechanisms. Some years experience in one or more of these fields is desirable, but recent and prospective graduates are also invited to apply. Mathematics graduates with experimental leanings are not excluded. Successful applicants will join teams engaged on research and advanced development projects. Publication of original work wherever possible is encouraged. Salaries are based on qualifications, experience and age, and are in keeping with present-day levels. General prospects within the organization are excellent. Apply to Personnel Officer, Mullard Research Laboratories, Cross Oak Lane, Salfords, near Redhill, Surrey, quoting reference E.R.L. W 2916

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

MULLARD RESEARCH LABORATORIES require Electronic Engineer(s) for interesting design and development work on laboratory instruments and test equipment. Applicants must be capable of working on their own initiative and should have academic qualifications ranging from City and Guilds Final Certificate or 4th year National Certificate (Radio) to Degree standard. Several years experience in electronics is desirable and a good knowledge of pulse techniques is preferred. The positions offered are permanent, progressive and carry attractive salaries. Applications should in the first instance be addressed to the Personnel Officer, Mr. G. A. Taylor, Mullard Research Laboratories, Cross Oak Lane, Salfords, near Redhill, Surrey, quoting reference VPL (C). W 2911

ONE OR TWO RESEARCH ENGINEERS are required by The English Electric Co. Ltd., at their Guided Weapons Division at Luton for extended studies into miniature high speed turbines and pumps, hydraulic servo systems and their associated control valves. The suitable men should be well qualified in mechanical engineering but an ability for original thought, and to work without supervision is of paramount importance. Salaries will be generous to the right applicants and housing assistance is possible. These posts offer excellent prospects for original work for which every facility will be offered. Applications to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 1181D. W 3023

NELSON RESEARCH LABORATORIES, English Electric Co. Ltd., Stafford, have a vacancy for a Physicist having an interest in solid state physics and electronics, to work on the fundamental properties and applications of materials suitable for use in electronic storage devices. An Honours Degree and some research experience are desirable. Salary at present-day levels in accordance with age and qualifications. Please reply to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 1353B. W 2979

NELSON RESEARCH LABORATORIES, English Electric Co. Limited, Stafford, have vacancies for Assistants in interesting work on the Physics, development and applications of magnetic and electrical insulating materials and devices. Graduates with or without industrial experience and people with National Certificates in Electrical Engineering or Physics are required. Reply to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 312A. W 2980

PHILIPS (BALHAM) WORKS LTD., 45 Nightingale Lane, S.W.12, require Graduate in Electrical Engineering or Physics for development of nucleonic and scientific instruments preferably with experience in electronics. Permanent appointment with excellent prospects. Pension Scheme. Applications should be addressed to the Personnel Officer. W 3004

PHYSICISTS required for applied research on the microwave properties of ferrites at a laboratory pleasantly situated in Northamptonshire. Applicants should have an Honours Degree in Physics. Previous experience of microwave techniques an advantage but not essential. Box No. W 3140.

PHYSICISTS AND ENGINEERS. Vacancies occur in the Aerodynamics Department of a rapidly expanding aircraft instrument firm engaged on the design and development of Autopilots for aircraft and helicopters. Substantial salaries are offered to men with experience of Aircraft Flight Trials and Stability and Control Analysis. Background in servomechanism an advantage. Please forward full details, with salary required (which will be treated in strict confidence) to: Personnel Officer, Louis Newmark Ltd., Prefect Works, Purley Way, Croydon. Hydraulic Engineer is urgently required by our rapidly expanding Aircraft and Industrial Control Department. Previous experience of flying control servosystems would be an advantage. The post involves direct liaison with manufacturers and applicants must, therefore, have the necessary personality. Substantial salary and excellent prospects. Apply: The Personnel Officer, Louis Newmark Ltd., Prefect Works, Purley Way, Croydon. W 3108

PROJECT ENGINEERS. To control and coordinate electronic and mechanical projects. Experience of estimating, planning, time and motion study desirable. A progressive position in expanding firm. High salaries. Superannuation scheme. Box No. W 3097.

PYE TELECOMMUNICATIONS Ltd., Ditton Works, Cambridge, invite applications for the following posts. Marine Sales Engineer to promote the selling of Marine Communication and associated equipment. Sales Engineer to promote the sale of communication equipment. Training given to suitable applicants lacking experience. Apply, giving fullest details to Personnel Manager. W 3147

QUALIFIED PHYSICISTS and Radar Engineers required to study problems involving microwave propagation in conjunction with newly-developed materials. Previous radar experience essential. Box No. W 3142.

RADIO ENGINEER for Bulawayo, Southern Rhodesia. Design and Development Engineer with at least five years' experience on domestic radio. Salary £1,200 per annum with free air passage to Rhodesia. Applicants will be interviewed in London. Application should be made to Box No. W 1320.

RADIO VALVE ENGINEERS. Vacancies exist for several Engineers to carry out Pre-Production, Quality Improvement and Testing work in connexion with an expanding programme of American type Miniature and Pinch type valves. Immediate work is available for fully experienced engineers and also for one or two juniors with the necessary technical background. Good salaries offered to the right applicants. Pension Scheme. Modern canteen, and other facilities available. Apply in writing to the Personnel Officer, British Tungsram Radio Works Limited, West Road, Tottenham, N.17. W 3079

R. B. PULLIN & COMPANY Ltd., invite applications for the following vacancies in their recently formed and expanding Electronic Development Division: (a) Senior Development Engineer. Applicants should possess an Honours Degree or equivalent qualifications, and should have had several years' experience of the development of electronic circuits, preferably including work on electrical servos and magnetic amplifiers. (b) Junior development engineer. Qualifications to O.N.C. or H.N.C. standard together with some previous experience of valve circuit design. The positions are of a permanent nature; they offer excellent prospects and the opportunity to work in a newly equipped Laboratory on a variety of projects requiring considerable individual technical responsibility and initiative. A commensurate salary will be paid. Contributory pension scheme, canteen and recreational facilities. Applications will be treated as confidential, and should be made to the Superintendent Electronic Development Division, R. B. Pullin & Company Ltd., Phoenix Works, Great West Road, Brentford, Middlesex. W 3132

RESEARCH AND DEVELOPMENT ENGINEERS are required for work on Electronic Switching, Computing and Control Apparatus. Applicants should preferably have had experience of one or more of the above. A good university degree in engineering or physics would be an advantage. Further vacancies exist for Junior Engineers and Technical Assistants. Excellent opportunities for advancement to more senior positions. Starting salary, according to qualifications and experience, will be in the range of £400 to £1,100 per annum. The Company operates a Superannuation Scheme and offers attractive working conditions with generous holiday and leave arrangements, and good social and recreational facilities. All applications will be dealt with in confidence and should be addressed to the Director of Research, British Telecommunications Research Ltd., Taplow Court, Taplow, Bucks. W 2957

RESEARCH ENGINEERS — preferably of Degree standard, and with a sound knowledge of communications and, particularly electronics required for experimental work relating to underwater sound apparatus. Applications giving past experience, technical qualifications, age and salary required, should be addressed to the Personnel Manager, Kelvin & Hughes Ltd., New North Road, Barkingside, Ilford, Essex. W 2958

SCIENCE GRADUATE aged 21-26 required in Tolworth, Surrey area, for investigation and development work on Ceramic dielectrics. Sound electrical knowledge essential. Some experience in this field an advantage. Consideration will be given to man not yet qualified but who intends to do so. Box W 1318.

SCIENCE GRADUATE or equivalent required for development work on dielectrics. Knowledge of one or more of the following an advantage—statistical methods, polymers, electrical measurements, insulating materials. Very good prospects and conditions of service. Men interested to visit the works should write or telephone the Personnel Manager, for an appointment. Telephone Manufacturing Co. Ltd., Sevenoaks Way, St. Mary Cray, Kent. Orpington 26611. W 3053

SENIOR AND JUNIOR RESEARCH PHYSICISTS preferably with University or Industrial Research experience are required to undertake basic research work on Thermionic Emission and related aspects of service physics. Wide scope and good prospects for men with initiative. Applicants should write to the Manager, Research Department, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, giving particulars of their age, qualifications and experience and suitable references. W 2883

SENIOR AND JUNIOR design draughtsmen required for interesting work in connexion with electronic equipment, commercial radio and television and/or light electro-mechanical engineering. London area. The positions vacant offer ample scope and opportunity for future advancement to men of good ability. A high salary will be paid to the selected candidates. All recognized staff privileges available. Please reply, giving full details of experience to Box No. W 3008.

SENIOR DESIGN AND DEVELOPMENT ENGINEERS required for work of an interesting nature in connexion with Microwave, Electronic and Mechanical development of Guided Weapons and associated equipment. The vacancies offer ample opportunity for advancement in a modern laboratory. The positions are permanent and the commencing salaries will be in accordance with experience and will be based on a generous and progressive scale. Degree or H.N.C. Please reply, in confidence, giving full particulars to: The Personnel Manager, The Plessey Company Limited, Vicarage Lane, Ilford, Essex. W 3070

SENIOR DRAUGHTSMEN. Due to expansion of the Electronics Division of the Plessey Company Limited there are several vacancies for experienced men in the following fields: 1. Design of a wide range of electronic equipment, including work to Service requirements. 2. Mechanical design of precision mechanisms for quantity production. These vacancies carry attractive salaries and long term prospects in reward for hard work and offer good staff conditions including superannuation and insurance schemes. Applications, which will be treated in confidence, should be addressed to: The Plessey Company Limited, Vicarage Lane, Ilford, Essex. W 3052

SENIOR ELECTRONIC ENGINEER wanted to take charge of Field Project for initial period of 18 months. Age Group 27 to 35. Must be single and medically fit and prepared to take complete charge of organization, administration and technical supervision of team in isolated situation abroad. Qualifications

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

required B.Sc. Degree or H.N.C. plus at least three years' experience in electronics or Final Cert. Five years' Course C. & G. Good prospect of permanency in large and expanding organization. Overseas salary £1,250 to £1,400. Box No. W 3139.

SENIOR ESTIMATORS required for an electronic engineering company employing 1,500 personnel. Candidates should have a comprehensive experience of the electronics and/or light electro-mechanical engineering fields with special emphasis on Ministry contracts. These are attractive vacancies and call for men who can justify a good salary. Superannuation scheme in operation. London area. Please reply, in confidence, giving full details to Box No. W 3009.

SENIOR TELECOMMUNICATIONS Engineer A well known and expanding electronic engineering Company in the London area requires a Senior Telecommunications Engineer to take control of a department dealing with Microwave Link Systems. Applicants should have had considerable previous experience, both in design and application, in this field; preferably holding at present a position as deputy head of a large telecommunications department. A very substantial salary is offered, and a Pension Scheme is in operation. Applicants should be of British Nationality. Please rep'y stating age, experience, etc., to Box E.E 872 c/o, 191 Gresham House, E.C.2. W 214

SENIOR TECHNICAL ENGINEERING STAFF. A London Engineering Company invite applications from Project Engineers who are capable of taking charge of Microwave, Electronics and Mechanical Engineering development in connexion with Guided Weapon and other applications. These positions are permanent and offer ample opportunity for further advancement. The commencing salaries, which will be in the region of £1,000 per annum upwards according to qualifications and experience, will be subject to review on a generous scale. Engineering degree or H.N.C. Replies, which will be treated in utmost confidence, should give full details of qualifications and experience and be addressed to Box No. W 3055.

SENIOR TRANSFORMER DESIGNER required to take charge of Design Office dealing with small transformer, power, audio, pulse, etc. Excellent prospects for an engineer with practical experience as well as academic knowledge. London area. Box No. W 3093.

SHORT BROTHERS & HARLAND LIMITED wish to engage Senior Engineers, Engineers and Technical Assistants for the Electronics Section of their Research Department, to work on Guided Missiles, Computing Systems, Navigational Equipment, and other interesting projects. Applicants should preferably have experience of servo-mechanisms, precision electronic or radio circuits, instruments or test gear. Qualifications required are: Senior Engineers—Honours Degree with at least five years' good engineering experience, and the ability to control a development team. Engineers—University Degree, or equivalent, with several years' experience of development work. Technical Assistants—H.N.C. or equivalent with good practical experience in appropriate field. These are permanent positions in an expanding organization with new and well-equipped laboratories. Good salaries and prospects for men with initiative; pension scheme; assistance with removal and housing. Interviews can be arranged either in London or Belfast. Applications will be treated as strictly confidential. Send full particulars of age, qualifications, experience with salary required to Staff Appointments Officer, Short Brothers & Harland Limited, P.O. Box 241, Belfast, quoting Ref. No. S.A.31. W 2952

SHORT BROTHERS & HARLAND LIMITED have vacancies in their Research Department for two mathematicians to undertake the theoretical investigation of automatic controls, navigational systems, etc. Applicants must possess an Honours Degree, and some experience of electronic, instrument or servo systems. Good salary and prospects in a rapidly expanding organization. Pension Scheme; assistance with housing and removal. Interviews can be arranged in London or Belfast. Applications will be treated as strictly confidential. Send full particulars of age, qualifications, and experience to—Staff Appointments Officer, Short Brothers & Harland Limited, P.O. Box 241, Belfast, quoting Ref. No. S.A.34. W 2953

SHORT BROTHERS & HARLAND LIMITED wish to engage Senior Engineers, Engineers and Technical Assistants for the Electro-Mechanical Section of their Research Department for work on Automatic Controls, Navigational Systems and other interesting military and commercial projects. Applicants should have had some experience of instruments, small Electro-magnetic devices, gyroscopes, or systems employing such components. Qualifications required are: Senior Engineers: Honours Degree plus at least five years' good engineering development experience, and the ability to control a development team. Engineers: University Degree, or equivalent, with several years' experience of development work. Technical assistants: H.N.C. or equivalent, with good practical experience in appropriate field. These are permanent positions in an expanding organization with new and well-equipped laboratories. Good salaries and prospects for men with initiative; pension scheme; assistance with removal and housing. Interviews can be arranged either in London or Belfast. Applications will be treated as strictly confidential. Send full particulars of age, qualifications, experience with salary required to Staff Appointments Officer, Short Brothers & Harland Limited, P.O. Box No. 241, Belfast, quoting Ref. S.A.32. W 2954

SIEMENS BROTHERS & CO. LTD., require technicians for their Research Laboratories at Blackheath S.E.3, engaged in work on electronics and telecommunications. Pensionable staff posts with good prospects of advancement. Apply in writing to Siemens Brothers & Co. Ltd., Ref. 744/12, Woolwich, S.E.18, giving particulars of age, qualifications, training, experience and salary required. W 3047

SIEMENS BROTHERS & CO LTD., have vacancies in their laboratories at Woolwich for Assistant Engineers to carry out experimental work on electronics as applied to long distance telephony. The work covers multi-channel carrier current telephony and telegraphy over long distance open-wire lines and cables in addition to V.H.F. and U.H.F. radio circuits. Field trials for such new equipments afford opportunities for short periods of overseas experience, and young engineers can obtain overseas installation experience. The laboratories are also engaged on the development of specialized carrier current terminal equipment for use with submarine cable systems employing submerged repeaters. Opportunities are available for dealing with mechanical design, the physical principles of component design and the miniaturization of equipment. There are vacancies for young engineers who wish to take up sales and project engineering work involving commercial as well as technical requirements. This work necessitates a period of laboratory training before undertaking overseas travel. Applicants should have Ordinary National Certificate or higher qualification. Experience in the maintenance of multi-channel carrier telephone or telegraph equipment an advantage. Apply Siemens Brothers & Co. Ltd., Ref. 744/11, Woolwich, S.E.18. W 2964

SIMMS MOTOR UNITS LTD. require a Laboratory Assistant for the research and development of electronic and electro-mechanical mechanisms associated with the commercial vehicle industry. H.N.C. or equivalent standard. Apply by letter stating age, qualifications and experience to Personnel Manager, Simms Motor Units Ltd., Oak Lane, Finchley, N.2. W 1317

SMITHS AIRCRAFT INSTRUMENTS have vacancies at Cheltenham for 2 Senior Engineers in their Engine Controls Laboratory for research and development on Gas Turbine electrical servo control equipment. Applicants, who should have a University Degree, A.M.I.Mech.E., A.M.I.E.E., A.F.R.Ae.S., or similar qualifications, must be capable of leading a small team, and have experience in, and a knowledge of one of the following: (a) Theoretical and/or practical aspects of servo mechanisms. (b) Electronics. (c) Magnetic amplifiers. These posts are permanent, and salaries will be within the range £1,000-£1,500. A Pension Scheme is available. Applications should be made to the Personnel Manager, S. Smith & Sons (England) Ltd., Bishops Cleeve, Cheltenham, quoting ref.: 56/EN. W 1322

TECHNICAL ASSISTANTS required for development of electromechanical and electronic instruments (Marine). Work involves initial experiments, sea-going trials, pre-production models and factory liaison. Occasional visits Overseas are arranged. Qualifications—Practical: 5 years Workshop or Drawing Office experience. Academic: City & Guilds Telecommunications Finals Group Certificate, or equivalent. Applications, stating salary required, should be addressed to the Personnel Manager, Kelvin & Hughes Ltd., New North Road, Barkingside, Essex. W 3077

SPECIAL PURPOSE MACHINERY and equipment design draughtsmen required. O.N.C. least qualification, but H.N.C. preferred. Men with imagination and initiative to develop original ideas with minimum direction. Basic applied electrical knowledge an advantage. Rates substantially above normal minimum for men with suitable experience. Five-day week, staff pension scheme, modern welfare amenities. Apply Personnel Superintendent, The Edison Swan Electric Co. Ltd., Cosmos Works, Brimsdown, Enfield, Middlesex. W 3062

TECHNICAL SALES MANAGER with sound know'edge of Television. Give full details education, technical qualifications, sales experience, knowledge of overseas countries and languages spoken. Reply, Ferguson Radio Corporation, Export Division, 105 Judd Street, W.C.1. W 3133

TELEPHONE CABLE ENGINEER. British Insulated Callender's Cables Ltd., require an experienced engineer to specialize in telephone transmission and distribution schemes. In this rapidly expanding field the post offers good opportunities for the right man. Applicants should have a good technical background coupled, preferably, with experience in the design or installation of telephone cable systems. Some experience of the associated terminal and repeater equipment would be an advantage. Replies quoting reference number P/88/55, should be addressed to the Staff Officer, B.I.C.C. Ltd., Prescot, Lancs. W 3143

TELEPHONE ENGINEERS. A well-known London company manufacturing Telecommunications equipment have vacancies in their Sales Section for (a) Engineers for preparing tenders, (b) Engineers for editing and writing technical publications, (c) Engineers for instructing and training customers' engineers. Should have good knowledge of carrier telephone and V.F. telegraph systems. Canteen and Sports Club facilities. Pensionable Staff posts. State age, qualifications and experience. Box No. W 2965.

TEST ENGINEERS are required by a Leading Midlands Manufacturer for:— (1) Testing and Fault Finding on Radar Units and other Electronic Devices. (2) Construction and maintenance of Test Equipment. (3) Testing and Fault Finding on domestic Radio and Television Receivers. These progressive positions cover a wide range of activities and selection will be made not only on experience but also on ability to respond to further training. Ex-Service technicians are particularly suitable. Applicants should write, giving details of career to date and salary expected to the Personnel Manager. (Ref. GLB), Box No. W 3036.

TESTERS required for high-grade Radar and Electronic work. Ordinary or Higher National Certificate an advantage, but men with suitable Service or Civilian experience will be considered. Opportunities of advancement available for progressive candidates. Good rates of pay, canteen facilities, etc., etc. Apply to the Employment Department, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17. W 2786

THE BRITISH THOMSON-HOUSTON Co. Ltd., require graduate engineers and Physicists for the design construction and processing aspects of magnetron and other electronic valve developments. The work is carried out in close association with a small machine shop

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 *inclusive or a woman aged* 18-59 *inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order,* 1952.

and pilot production unit and every encouragment is given to the development of new ideas. It is work in which both practical and theoretical interests are desired. Applicants should write to the Director of Research, British Thomson-Houston Company Ltd., Rugby, giving their age, qualifications and experience and quote reference FT. W 3115

THE BRITISH THOMSON-HOUSTON Co. Ltd., require a Physicist or an Electrical Engineer in their research laboratory at Rugby for work connected with the development of new types of electric lamp. In addition to the determination of the Physical design and measurement of electrical and optical characteristics, the work involves the development of the associated circuitry which is often of special nature. Applicants are invited to send particulars of their qualifications to the Director of Research, British Thomson-Houston Co. Ltd., Rugby, quoting reference BE. W 3114

THE EDISON SWAN ELECTRIC COMPANY LTD., have vacancies in their Special Products Development Laboratory for Engineers for Development work on a wide range of electronic instruments and apparatus for Medical, Industrial and Government use. Please write, stating experience, age and salary required to 155 Charing Cross Road, London, W.C.2, reference SP/LAB. W 213

THE GENERAL ELECTRIC CO. LTD., Brown's Lane, Allesley, Coventry, requires Mechanical Development Engineers, Designer-Draughtsmen and Draughtsmen, preferably with experience of Radar type equipments for work on Guided Weapons and like projects. Also required, Senior and Junior Electronic Development Engineers, particularly in the field of Microwave and Pulse Applications. Salary according to age, qualifications and experience. Apply by letter stating age and experience to the Personnel Manager. Ref. R G. W 208

THE PLESSEY COMPANY LIMITED needs Engineers for Radio and Television. Experience in Circuit Design and Company Design advantageous. Will interested persons please write, with full details to Mr. J. Rhys-Jones, The Plessey Company Limited, Boreham Wood Laboratories, Manor Way, Boreham Wood, Herts. W 3076

THE TELEGRAPH CONDENSER CO. LTD., invite applications from Engineers fully experienced in Radio and Television design to assist Chief Development Engineer in development of printed circuits. Qualifications at least to A.M.I.E.E. standard. This position offers scope for the right man who must be capable of initiating and following projects to finality, including contact with customers. Superannuation scheme. Write giving full details of qualifications and experience, age and salary required, to Personnel Manager, T.C.C. Ltd., North Acton, W.3. W 2932

THE TELEGRAPH CONDENSER CO. LTD., require Radio and TV Engineer with laboratory experience for work in connexion with printed circuits. H.N.C. standard. Superannuation scheme. Write giving full details of education and experience, age and salary required to Personnel Manager, T.C.C. Ltd., North Acton, W.3. W 2933

THREE MEN FROM COLLEGE with a good degree in light electrical engineering in electronic equipment and small mechanical apparatus in audio frequency field, also one with a degree and experience in planning, installation of electronic equipment, preferably with film studios. Personnel Manager, Westrex Company Ltd., Coles Green Road, N.W.2. W 1315

TRANSFORMER DESIGNER required for development projects involving audio-frequency power transformers, pulse transformers, oil-filled units, etc. Apply stating age, qualifications and experience to the Personnel Manager (Ref. R.G.), The General Electric Co., Ltd., Brown's Lane, Allesley, Coventry. W 192

TRANSFORMER and Filter design Engineer required to take charge of design and manufacture. Qualifications and experience essential Apply, to Personnel Manager, Pye Telecommunications Ltd., Ditton Works, Cambridge. W 2930

TWO DRAUGHTSMEN required for work on interesting electronic development for small progressive Company near Southampton. Reply stating age, qualification, experience and salary expected to Box No. W 1330.

TWO GRADUATE PHYSICISTS or electrical engineers with an interest in electronic engineering are required for the development of equipment for the measurement of the properties of semiconductor materials and devices. Previous experience in the design and construction of electronic equipment is desirable for one of the vacancies. Box No. W 2922.

ULTRA ELECTRIC LTD., Western Avenue, Acton, W.3 announce the following vacancies for Engineering Staffs. (1) Television Development. (a) Senior Engineers required for T.V. Receiver design. Applicants should have good academic qualifications and experience of the design of radio frequency amplifiers, preferably up to frequencies of the order of 200 Mc/s. (b) Senior Engineers for Time Base development. Applicants should have good academic qualifications and previous experience in the design of T.V. Scanning circuits. (c) Junior Engineers with academic qualifications or experience in T.V. Receiver development. (2) Radio Development. (a) Senior Engineers required for development of radio receivers. embodying the most recent AM/FM techniques. Knowledge of F.M. receiver design desirable. (b) Junior Engineers required for receiver design; experience desirable but not essential if possessing Higher N.C. or C. and G. (Telecoms.) Final Cert. (3) Electronics. (a) Senior Electronics Engineer with some experience of circuit design for work in one of the following: (i) Pulse techniques and general waveform circuitry. (ii) Radar Display. (iii) Feedback techniques at video frequencies. (iv) Simple Servo devices. Successful applicants will have opportunities of studying recent American techniques and they should be capable of accurate recording of experimental and design data and the preparation of technical servicing information. (b) Electronic Engineers for work on one or more of the above subjects. (4) Test Equipment Development. (a) Test Equipment Development Engineer for design and development of production test equipment for T.V., radio or contract work. Applicants should have Higher N.C. or equivalent and good experience. (b) Junior T.E. Engineer with some qualifications or preferably some experience. (c) Measurements Section Laboratory Assistant (m. or f.) with some technical knowledge and experience of calibration and certification of electronic equipment. Applicants are requested to write to the Personnel Manager, stating which of the post(s) desired and giving full details (in strictest confidence) including age, experience and salary expected. Saturday morning interviews can be arranged if desired. W 3031

URGENTLY REQUIRED single young men as Electronic Wiremen, assemblers and fitters, also Junior and Senior Test Engineers in connexion with Television Cameras and ancillary equipment. Apply in writing to Personnel Office, Dept. 24, Pye Ltd., Radio Works, Cambridge. W 3145

WINSTON ELECTRONICS LTD. have a vacancy for an engineer in their development laboratories. Applicants should have several years' experience on audio frequency circuits, in addition to general electronic circuit knowledge, and would be required to work on loudspeaking telephone equipment. A reliable man is required, who can cope both with development work, and with installation queries. Apply in writing to Chief Engineer, Winston Electronics Ltd., 1 Park Road, Hampton Hill, Middlesex. W 3094

Further "Situations Vacant" advertisements appear in display form on pages 85, 110, 119, 137 and 140.

SITUATIONS WANTED

ELECTRONIC ENGINEER, 36. Degree, executive, 14 years' electronic experience, versatile, inventive ability, flair for original and precision work, G W. experience, seeks senior progressive post where integrity, enterprise and ability to achieve greatly improved results are appreciated. Salary range £1,000-£1,200, with house. British. Home Counties preferred, but not essential. Box No. W 1335.

EXECUTIVE ENGINEER with 15 years' electronics experience seeks responsible post where drive and initiative will be adequately rewarded. Box No. W 1333.

SENIOR TRIALS ENGINEER with several years' experience in guided weapon field, seeks position of responsibility where organizational ability can be usefully employed. Experience includes development, test and instrumentation embracing guidance and control. Comprehensive experience of trials including period spent in Australia, covering part and overall responsibility for Missile. Fully mobile and well used to arduous and responsible work involved. Position more important than salary. Box No. W 1332.

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MAGSLIPS. SELSYNS and many other items connected with automatic and remote control mechanisms are marketed by Servo & Electronic Sales Ltd. Brochure available on request See our display advertisement on page 140. W 202

METAL-GLASS SEALS. Single way hermetically sealed terminals for soldered connexions and fixing. Mostly 1kv and 2kv sizes. New: 65s. per 1,000 assorted. P. B. Crawshay, 94 Pixmore Way, Letchworth, Herts. Tel. 1851. W 215

POWER EQUIPMENT BARGAINS. Potted Mains Transformers. These are of really superior construction fitted in cast metal cases and compound filled. Terminals come to ebonite baseboard. All are upright mounting and have 220/230 normal 50 cycle mains input and fully screened primary. Type 5F1. 265-0-265 at 300 m.a.; 6.3 v. at 7 amp; 4.4 v. at 2.5 amp.; Price 35s. plus 3s. 6d. carriage. Type 5F2. 365-0-365 at 150 m.a.; 4 v. at 2.5 a.; 6.9 v. at 4.2 a.; Price 32s. 6d., carriage and packing 3s. 6d. Type 5F3. 1540 v. 2 v. at 2 a.; 4 v. at 1 a. This is an ideal transformer for televisors and scopes using V.C.R.97, etc. Price 25s. carriage 2s. 6d. Potted Chokes. These chokes are in similar type cases and therefore match the above transformers. Type 5F4. 5 H. at 300 m.a. Price 10s. carriage and packing 2s. 6d. Type 5F5. 10 H. at 150 m.a. Price 12s. 6d. post and packing 2s. 6d. High Power Transformers. For R.F. Heaters, transmitters, etc., etc. These are open wound type for maximum cooling and have the normal 200-250 primary fully screened. Type 5F6. 1,000 v. at ½ amp. e.g., 5 K.V.A. Price £8 10s., carriage and packing 5s. Type 5F7. 1,500 v. at 1 amp. e.g., 1.5 K.V.A. Price £15, carriage and packing 7s. 6d. Type 5M1. 1,000-0-1,000 v. at 1.5 amps. e.g., 1½ K.V.A. Price £12 10s., carriage and packing 7s. 6d. Type 5M2. 1,000-0-1,000 v. at 500 m.a. and 4 v. at 4 a. Price £7 10s., carriage and packing 4s. 6d. Type 5M3. 375-0-375 v. at 250 m.a. and 4 v. at 4 a. Price 37s. 6d., carriage and packing 3s. 6d. Power Filament Transformers. Type 5M4. 4 v. at 4 a. 2-0-2 v. at 10 a. Price 18s. 6d., carriage and packing 3s. 6d. Type 5M5. 3.15-0-3.15 at 10 a. 4-0-4 at 10 a. 4-0-4 at 2 a. 4 at 4 a. 2.5-0-2.5 at 3 a. Price 27s. 6d. plus carriage and packing 3s. 6d. Type 5M6. 34 v. at 2 a. tapped 32 v., 30 v. and 28 v. for relays, etc., 22s. 6d. plus 3s. 6d. carriage and packing. Power Chokes. Open wound type and feet with clamps. Type 5M7. 30 Henry at 500 m a., 35s. Type 5M8. 20 Henry at 500 m.a. 32s. 6d. Type 5M9. 15 Henry at 500 m.a. 27s. 6d. Type 5M10. 10 Henry at 500 m.a. 22s. 6d. Type 5M11. 25 Henry at 250 m.a. 18s. 6d. Type 5M12. 3 Henry at 10 amps. 18s. 6d. Type 5M13. 200 Henry at 5 m.a. 15s. E.P.E. Ltd., Special Sales Dept., 31 Bourne House, Grove Road, Eastbourne. W 185

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ROYAL TECHNICAL COLLEGE. Salford. Principal: P. F. R. Venables, Ph.D., B.Sc., F.R.I.C. Department of Pure and Applied Physics Session 1954-55. Post-advanced course on the Cathode-Ray Oscillograph (in collaboration with the Manchester and District Advisory Council for Further Education.) A course of lectures will be held on Friday, 20th May and Saturday, 21st May at the Royal Technical College, Salford. Fee for the course £1 11s. 6d. Lecturers: R. Feinberg, Dr.-Ing., M.Sc., A.M.I.E.E. Ferranti Ltd., J. A. Darbyshire, M.Sc., Ph.D., D.I.C., A.M.I.E.E., Ferranti Ltd., H. Meyer, Ph.D., A.R.I.C. Derby and Co. Ltd., K. C. Burn, B.Sc., Ferranti Ltd., E. A. Edis, B.Sc. (Hons.), A.M.I.E.E. A. C. Cossor Ltd., M. S. Richards, M.A. (Oxon.), A.M.I.E.E. Mullard Radio Valve Ltd., J. Cook, Grad.I.E.E. Mullard Radio Valve Ltd., A. S. Husbands, B.Sc. (Eng.), A.M.I.E.E. Metropolitan-Vickers. Details of the course and enrolment forms may be obtained from W. G. Darvell, M.Sc., F.Inst.P., Head of the Department of Pure and Applied Physics, Royal Technical College, Salford 5. W 3105

T.V. AND RADIO—A.M.Brit. I.R.E., City & Guilds, R.T.E.B. Certificate, etc., on "No Pass—No Fee" terms. Over 95 per cent successes. Details of Examinations and Home Training Courses in all branches of Radio and T.V. Write for 144-page handbook — Free B.I.E.T. (Dept. 337H), 29 Wright's Lane, London, W.8. W 187

UNIVERSITY OF EDINBURGH. Principal: Sir Edward Appleton, G.B.E., K.C.B., D.Sc., F.R.S. Diploma in Electronics and Radio. The one year post-graduate diploma course in Electronics and Radio will commence on October 11th 1955, and will provide specialized training for those wishing to proceed to research in this field, or to employment in industrial organizations. Applicants should hold an honours degree in electrical engineering, mathematics or physics. The main lecture courses are in network theory, principles of valve circuits, transmission and radiation theory, and particles in fields. Laboratory and field work will be arranged to support the lecture courses. A limited number of grants may be made available for suitable candidates. Further particulars and application forms can be obtained from the Secretary to the University, The University, South Bridge, Edinburgh. Charles H. Stewart, Secretary. W 3105

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BY ORDER of Imperial Chemical Industries Chamberlain & Willows will sell by Auction at Regent House, St. Philip's Place, Colmore Row, Birmingham, 6, on Wednesday, 22nd June 1955 at 2.30 p.m. The Important Freehold Factory Paul Street Works, Wolverhampton, forming an island block centrally situated in the Town. Total Covered Floor Area About 128,000 sq. ft. With vacant possession on completion also an adjacent Freehold Site with an area of about 3,500 sq. ft. with Vacant Possession. Particulars and conditions of Sale from the Auctioneers, Chamberlain & Willows, 23 Moorgate, London, E.C.2. (Tel. City 6013—8 lines). W 3110

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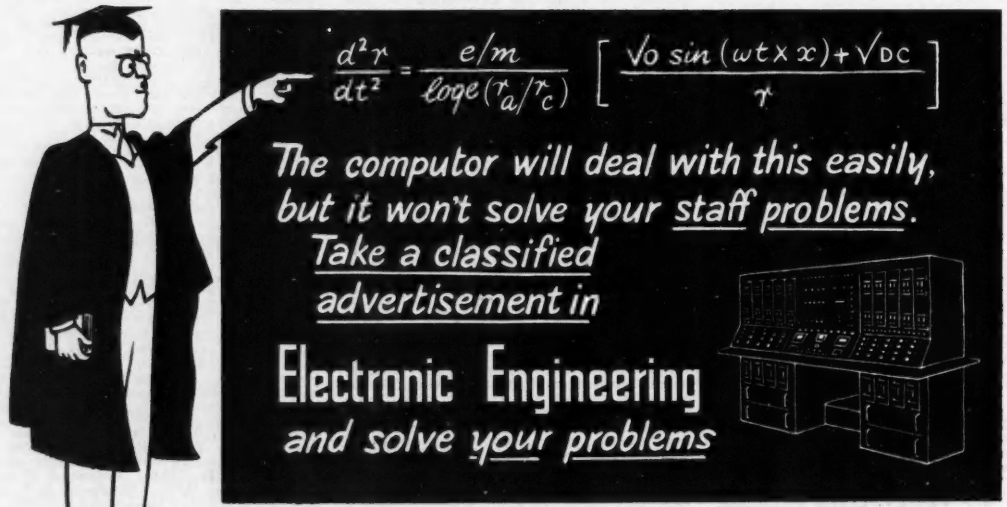
PARTNER sought, experienced valve engineer to start service reconditioning worn out C.R. tubes. J. Hersh, 84 Leeside Crescent, N.W.11. W 1336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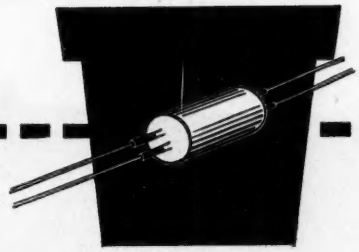
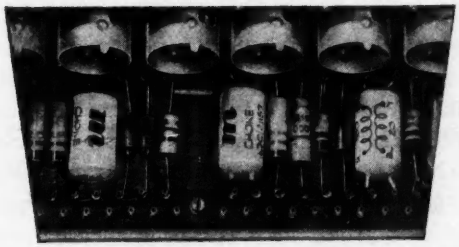


- New resin alloy and new potting techniques mean no cracking due to local stresses, no loss of moisture seal and ability to stand up to large acceleration stresses.
- Can withstand temperatures in range —65°C to +120°C without damage. Thermal conductivity is good, electrical losses are low, and high insulation resistance is maintained even at high temperatures.
- This 'wire-in' pulse transformer is contained in a resin block less than 1" long and ¼" in diameter. May be mounted by its leads on a tag panel. Simplifies inter-valve connections in pulse circuits, and is immediately adjacent to valves it couples.
- Many types of potted transformers and other components are available. If you want them (in small or medium quantities) get in touch with us—preferably in the early stages of development when minor modifications can still be made.



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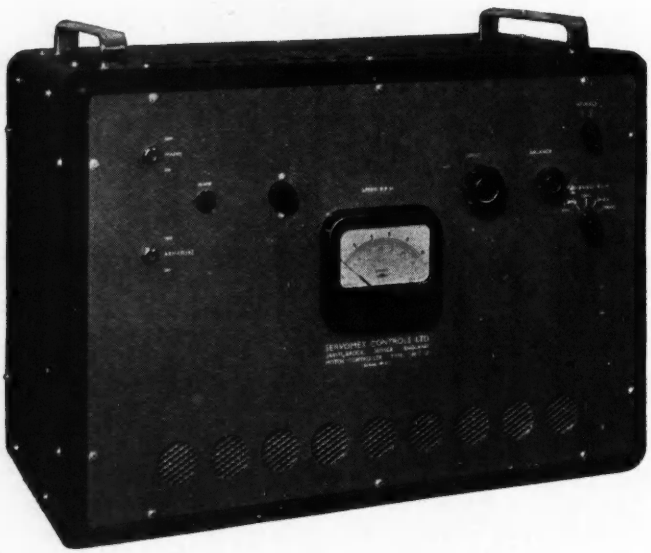

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A.C.2. 10 amp. *(for immediate delivery)*

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These Stabilisers both employ a continuous servo with velocity feedback. They are insensitive to change of frequency—load power factor—temperature—supply waveform. They are unaffected by vibration and bumping, and have excellent long-term stability. Other important features are :—

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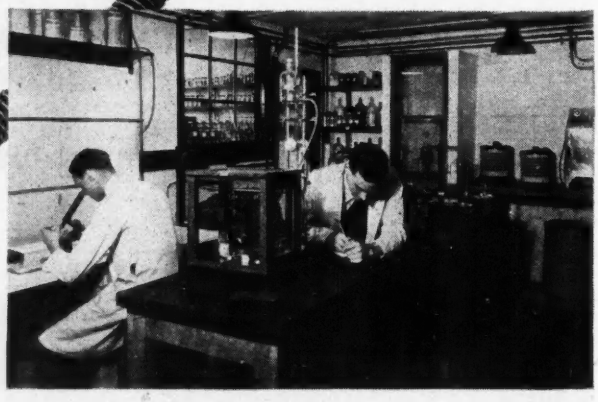

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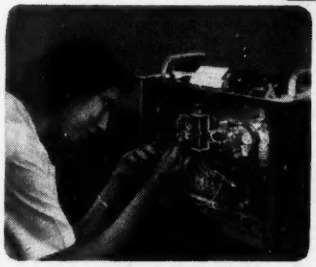
LOWER PICTURES show typical assembly and wiring operations in progress— one a ground/air transmitter for a European Air Force, and the other a sub-miniature communications receiver.

CENTRE PICTURE shows part of one of the wiring bays in our 8,000 square foot factory. Others sections are devoted to activities such as cable-forming and component assembly.



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A.I.D.-approved sub-contractors

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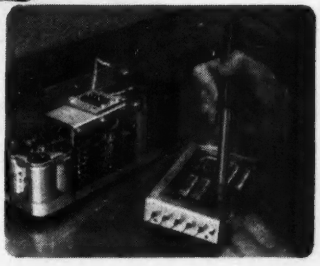

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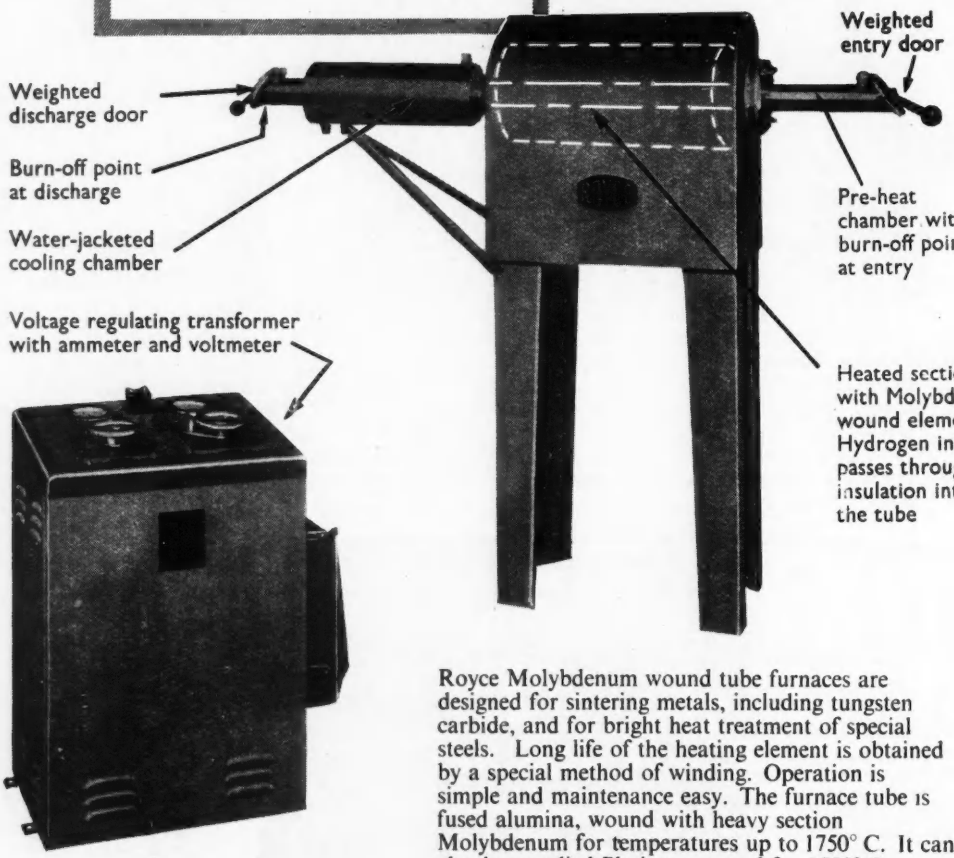
Molybdenum wound for temperatures up to 1750° C.


Weighted entry door
Weighted discharge door
Burn-off point at discharge
Water-jacketed cooling chamber
Pre-heat chamber with burn-off point at entry
Voltage regulating transformer with ammeter and voltmeter
Heated section with Molybdenum wound element. Hydrogen inlet passes through insulation into the tube

Royce Molybdenum wound tube furnaces are designed for sintering metals, including tungsten carbide, and for bright heat treatment of special steels. Long life of the heating element is obtained by a special method of winding. Operation is simple and maintenance easy. The furnace tube is fused alumina, wound with heavy section Molybdenum for temperatures up to 1750° C. It can also be supplied Platinum wound for 1550° C, Kanthal wound for 1200° C, and Nickel Chromium wound for 1000° C. Tube sizes range from 1" to 5" inside diam.

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ROYCE

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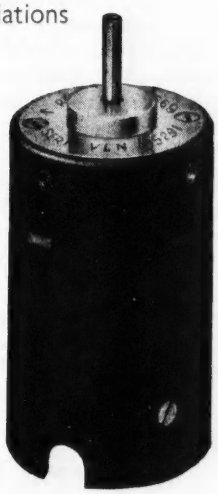
it's not usually just a matter of fits.

Guided weapons, servo-systems, transmitters and the like ask more of their motors than mere space economy. Maximum output with minimum weight and the widest range of speeds and torques, are absolute essentials. Typical of these small-size, high-power motors is the one shown actual size below with its performance details. Vactric produce eight types of permanent-magnet motor, some with 200 variations of characteristics to choose from.

Output	5.88×10^{-3} h.p.
Torque	80 gram centimetres 1.11 ounce inches
Speed	4000-6000 r.p.m.
Voltage	24 volts D.C.
Amps	0.5 max. amperes
Watts	11.5 watts
Rating	continuous

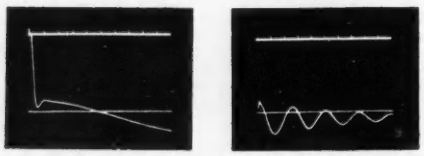


Telephone Sloane 9656 or write for brochure or technical assistance.

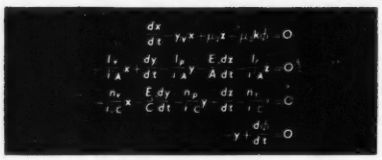
Vactric Limited 196 Sloane Street London SW1

About the analogue computor

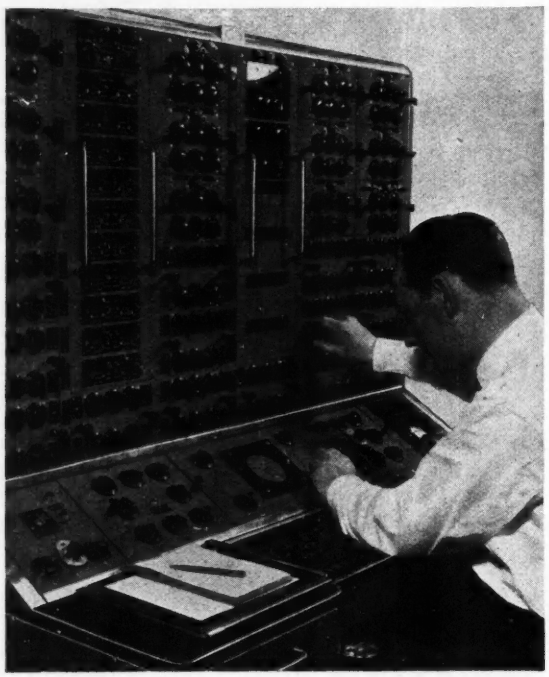
The electronic analogue computor makes patterns like this



which solve differential equations like these



IT RUNS THROUGH in a matter of hours a range of solutions that would take a team of mathematicians weeks to work out. You knew that? But did you know that Shorts are now making a general purpose analogue computor which can be harnessed, singly or in banks, to solve a wide variety of engineering problems? This, the first British analogue computor in production, will deal with linear or non-linear systems. Apart from the solution of differential equations, the instrument may be applied to the design of servo systems and to analysis and synthesis in connection with the behaviour and design of dynamic electrical, mechanical and thermal dynamic systems.
The Short Analogue Computor is described in a brochure which you will certainly find interesting and probably find profitable. A word to the address below and a copy will be sent to you.

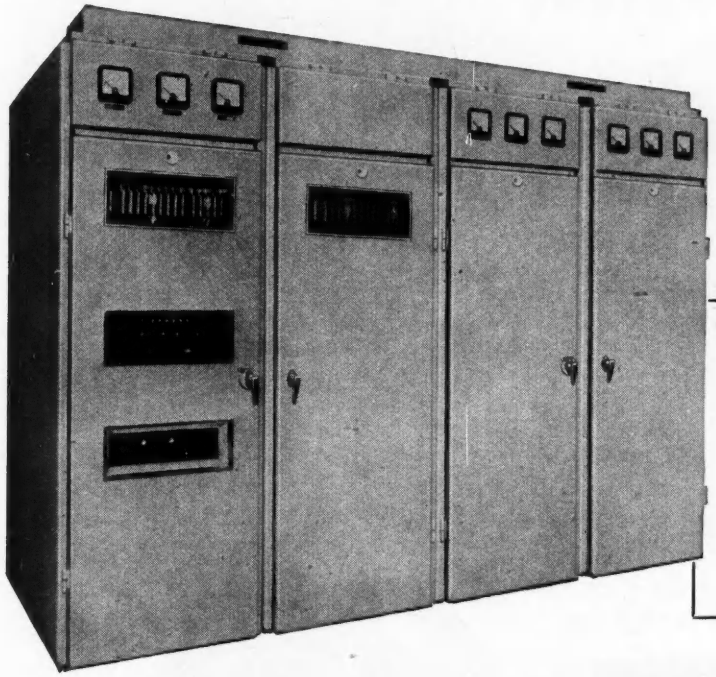


In one day at the console, an operator can set up problems and get answers that would take weeks of expensive study by normal means.

Here's the *Short* answer

Short Brothers and Har'and Ltd., Computor Sales Department, 208a Regent Street, London, W.1. REGent 8716

Marconi 6kW HF ISB Transmitters



TYPES HS 71 AND HS 72

The assembly is enclosed by unit sections, as shown here, with access through front and rear doors. The two left hand bays house the rectifier and power equipment and the right hand bays the low power and auxiliary transmitting circuits and the main output stage.

These transmitters, designed in accordance with the most advanced practice, provide :—

(a) Telegraphy on CW and FSK (A1 and F1)
(b) Independent Sideband Operation (A3b)

The drive equipment is external and provides either ISB modulation or telegraph keying at 3.1 Mc/s and suitable RF oscillator signals for frequency changing in the transmitter. HS 71 is manually operated; HS 72 provides full automatic tuning and selection of any one of six pre-set frequencies.

FEATURES INCLUDE

- **Tuning over the whole range without change of components**
- **Air cooling throughout, with dust filtering.**
- **Double screening of power stages reduces indirect radiation and cooling air noise.**
- **Envelope feed back to reduce distortion.**
- **Compact assembly with good access for servicing and safety interlocking.**

More than 80 countries now have Marconi equipped telegraph and communication services, many of which, completed 20 years ago, still give trouble-free operation.

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MARCONI'S WIRELESS TELEGRAPH CO. LTD., CHELMSFORD, ESSEX

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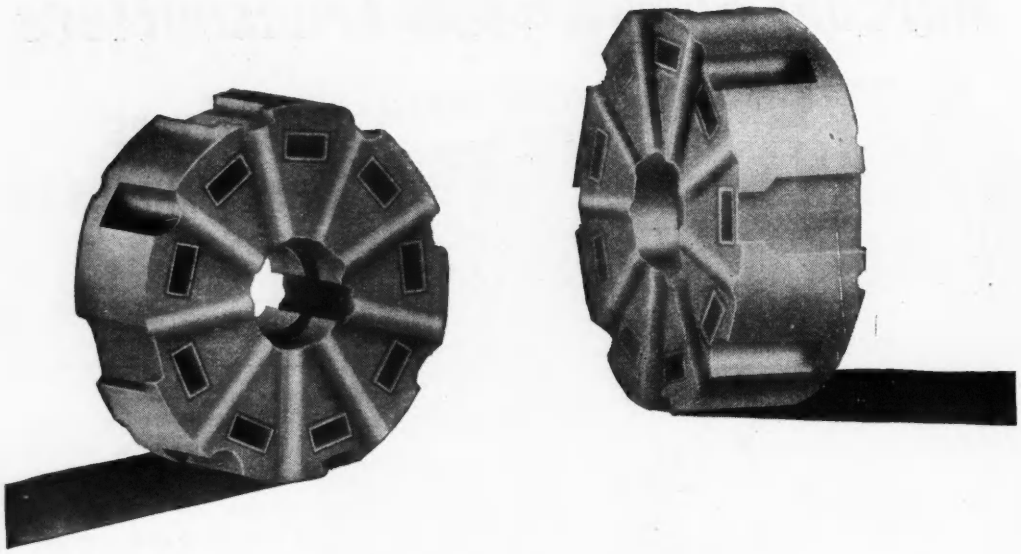
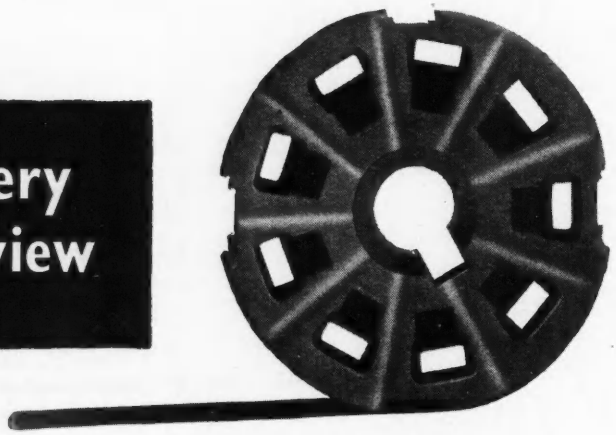


from every point of view



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S.P.67

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Four current ratings are at present available . . 0·25 mA, 1·5 mA, 7 mA and 10 mA at various D.C. voltages between 20 and 100V.

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Unistor Code	D.C. Current Rating in Max. Ambient Temp. 55°C.	D.C. Current Rating in Max. Ambient Temp. 71°C.	Maximum Continuous Inverse D.C. Voltage	Maximum Instantaneous Inverse D.C. Voltage	Capacitance at Approx. Zero Volts
	mA	mA	Volts	Volts	pF
Q1/1	0·25	0·25	20	56	20
Q3/1	1·5	1·5	20	56	65
Q6/1	7	3	20	56	500
Q8/1	10	4	20	56	1,000

SenTerCel UNISTORS

(asymmetric resistors)

Standard Telephones and Cables Limited

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THAT MEASURES

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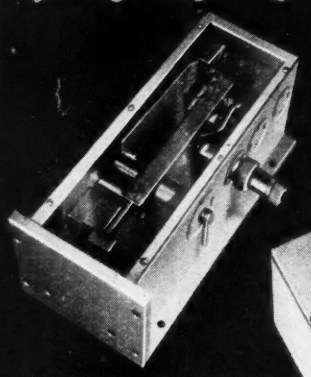

G 225 B
VIBRATION
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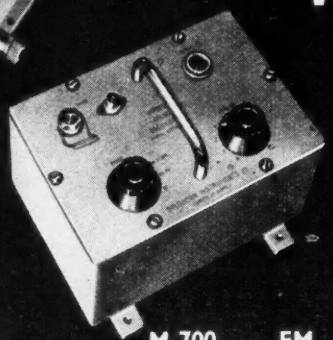

M 700 FM
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MR 220
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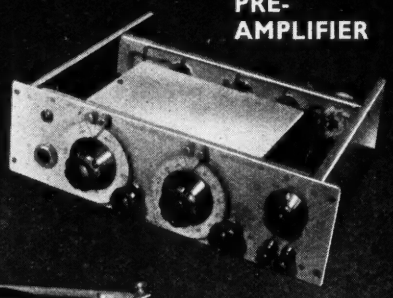
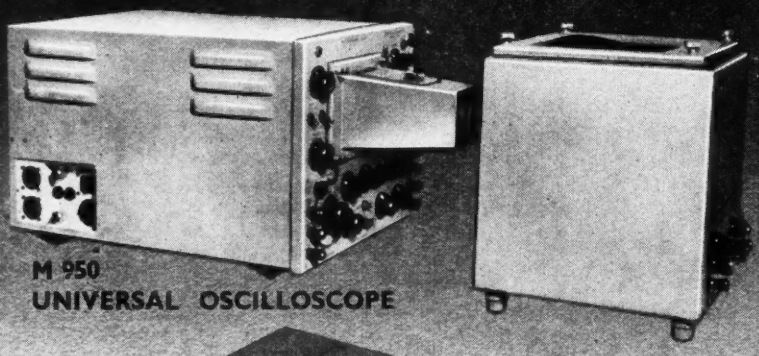
AMPLIFIER





M 950
UNIVERSAL OSCILLOSCOPE

M 731
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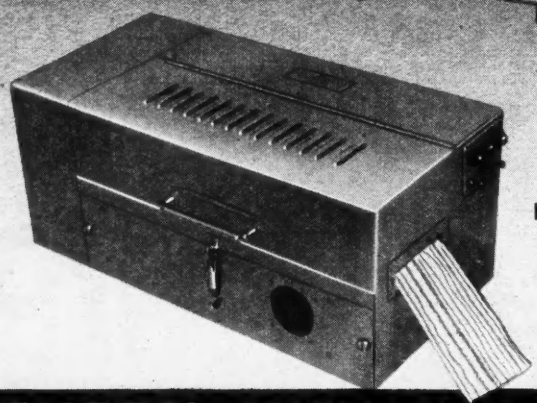
CAMERA



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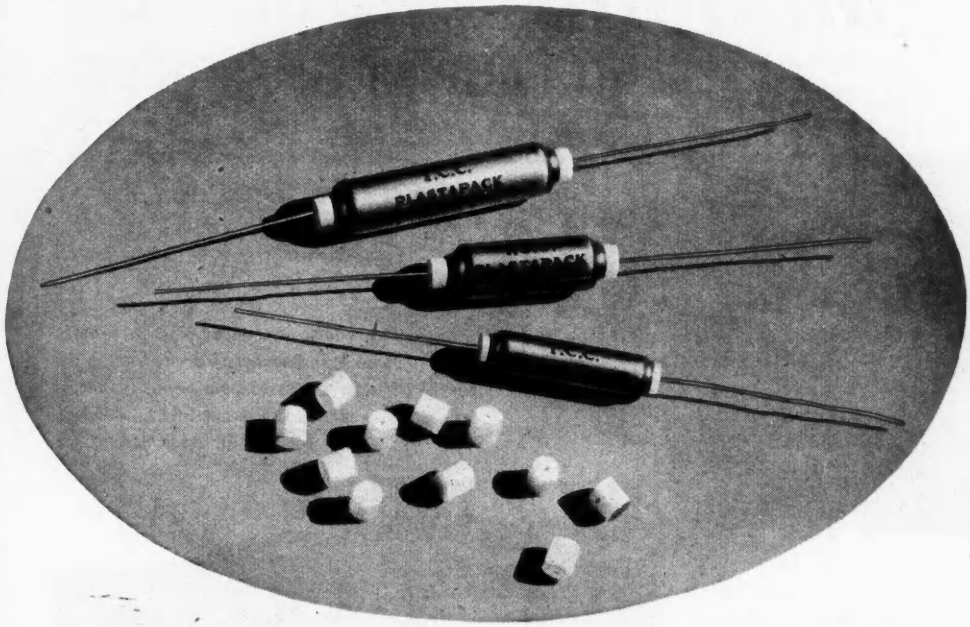

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holds its outstanding electrical properties even under very humid conditions

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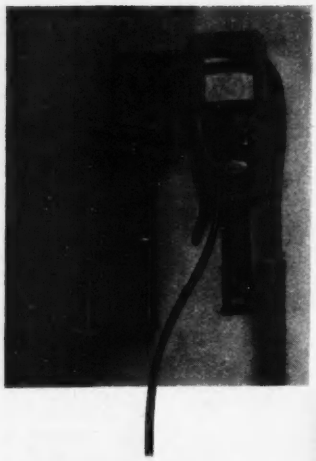
P.569

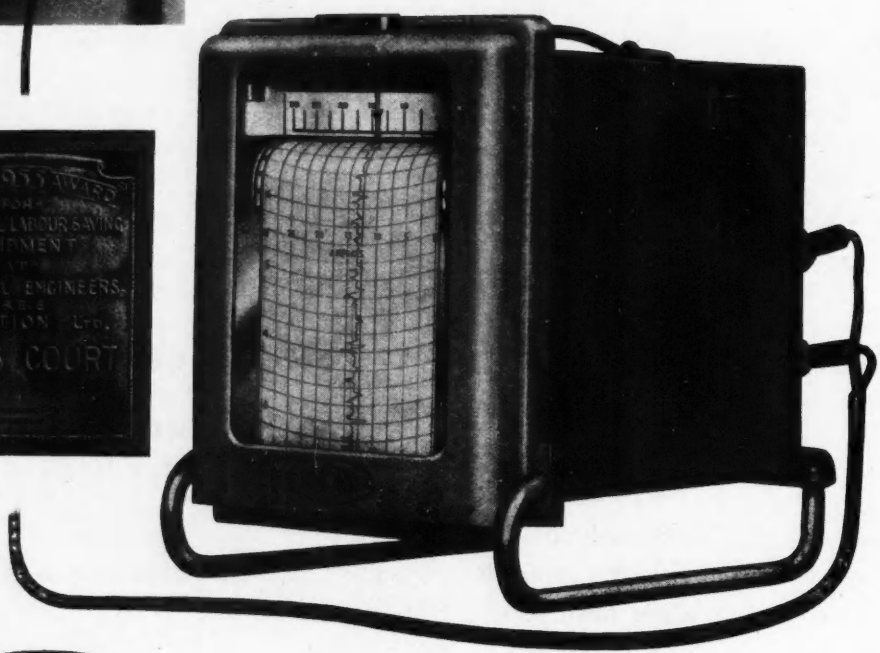
GRAPHIC RECORDER

WITH CLIP-ON TRANSFORMER



The combination shown provides 7 current ranges up to 600A. In addition the Recorder is provided with self-contained voltage ranges of 150, 300 and 600V. The whole forms an easily transportable Universal A.C. Recorder which is accurate, responsive and robust. Send for details

Record are proud to announce that their Graphic Recorder with Clip-on Transformer has been awarded the Silver Plaque for the best labour saving industrial exhibit at the recent A.S.E.E. Electrical Engineers' Exhibition at Earls Court.



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THE RECORD ELECTRICAL CO LTD

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OF INTEREST to all engineers, this new publication forms an invaluable reference to current G.E.C. electronic products suitable for such industrial applications as control instruments, scientific measurement, counting, radio-active indication, photoelectric alarms and indicating devices and electronic relays and voltage stabilisation. The technical information which includes ratings, dimensions, base connection diagrams and screen characteristics, enables the potential user to choose the device most suitable for a particular application.

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- **Barretters**
- **Cathode ray tubes** (instrument and special types)
- **Electrometer valves**
- **Geiger Muller tubes**
- **Photoelectric cells**
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- **Semi-conductors**
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OSRAM VALVE AND ELECTRONICS DEPT. FOR **OV 2507**

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And NOW—a range of 'CERAMICAPS' for your LAB Storage Unit!

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Ref.	Type	Loading	Max. Volts	Range	Dimensions
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T	⅛ watt	⅛ watt	250	10 ohms to 10 megohms	⅝" x ⅛"
R	¼ watt	1 watt	500		⅝" x ¼"
Tolerance available ± 20%, 10%, 5%					
HIGH STABILITY RESISTORS					
HS3	⅛ watt	⅛ watt	750	1 ohm to 500 megohms	1.1" x 0.1"
Tolerance available ±5%, 2%, 1%					
WIREWOUND RESISTORS					
5 ohms to 100K ohms — 5 - 10 watts					
'CERAMICAPS'					
Tubulars 3 - 470 pf Tolerances ±2%, 10% 500 - 5000 pf Hi-K					

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THE LAB TESTED CONTINUOUS **STORAGE UNIT**

★ **Continuous Storage for Resistors and 'Ceramicaps'**

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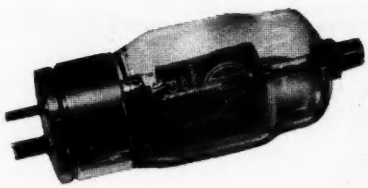

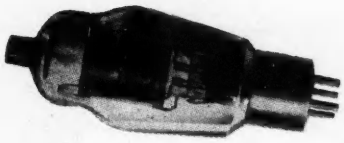

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These valves are suitable for a wide variety of control applications. The inert gas filling ensures stable operation over a wide range of ambient temperatures.

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Designed to discharge pulse-forming networks in high power, high voltage pulse generators. Short deionization time and low time jitter provide for precise triggering at high repetition frequencies.

Technical data sheets are available on request.

Type	Filling	Max. Dimensions		Filament or Heater		Max. Peak-Inverse Voltage (Volts)	Max. Peak-Forward Voltage (Volts)	Max. Peak Current (Amps)	Max. Mean Current (Amps)	Approx. Tube Drop (Volts)	Peak Power Level (a)	American Equiv.	C.V. Number
		Length (MM)	Dia. (MM)	Volts	Amps (Approx.)								
AFX.212	Xe	54	19	6.3	0.25	350	350	0.11	0.025	11	—	6D4	1949
AFX.203	Xe	176	57	2.5	4.0	300	280	1.7	0.40	11	—	C1A	2868
FX.215	H_2	286	97	2.5	27.5	16,000	16,000	200	0.20	100(b)	2.0×10^9	—	2203
FX.219	H_2	222	65	6.3	10.6	16,000	16,000	325	0.20	100(b)	3.2×10^9	5C22	2520
FX.225	H_2	175	65	6.3	6.1	8,000	8,000	90	0.10	100(b)	2.0×10^9	4C35	1787
FX.227	H_2	132	40	6.3	2.25	3,000	3,000	35	0.045	100(b)	0.3×10^9	3C45	372

Xe — Xenon H_2 — Hydrogen

(a) — Product of Peak forward Voltage, Peak Current and pulse repetition frequency.

(b) — Under conditions of pulse operation.

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ENGLISH ELECTRIC VALVE CO. LTD.

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Telephone: Chelmsford 3491

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PLUG REF. 736022
SOCKET REF. 736023

This cable mounting elbow connector is the latest addition to our well-known range of plugs and sockets complying with R.C.S. 322. For full details please write.

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POWER CONTROLS
LIMITED

EXNING RD., NEWMARKET

PHONE: NEW 3181/2/3

A HIGH Mu PENTODE
with low hum, noise and microphony

TYPICAL OPERATING CONDITIONS				
Anode Voltage (Va)	250	250	250	250
Screen Voltage (Vg_2)	80	100	160	200
Grid Bias (Vg_1)	1.25	1.7	2.75	3.5
Anode Current (mA)	7.8	7.9	10.5	12.3
Screen Current (mA)	2.45	2.5	3.3	3.85
Mutual Conductance (mA/V)	7.0	7.0	7.45	7.6
Anode AC Resistance (ra) (Megohms)	0.55	0.55	0.4	0.3
Input Capacity (Hot) ($\mu\mu$F)...	20	19.9	19.7	19.5

RATING		
Heater Voltage	V_h	4.0
Heater Current (Amps)	I_h	1.0
Maximum Anode Voltage	V_a	250
Maximum Screen Voltage	Vg_2	250
Mutual Conductance (mA/V)	g_m	7.7

Taken at V_a=250; Vg_2=100; Vg_1=1.5

BASE

British 7 pin
Pin No. 1 Metallising
Pin No. 2 Anode
Pin No. 3 Suppressor Grid (g_3)
Pin No. 4 Heater
Pin No. 5 Heater
Pin. No. 6 Cathode
Pin No. 7 Screen (g_2)
Top Cap Control Grid (g_1)

The AC/SP3 RH is available in two grades. The valves in both grades are characteristically identical, the grading 'A' or 'B' relating only to relative levels of hum, noise and microphony. B Grade valves are suitable for the majority of applications, but for particular applications where the noise level is very important Grade A may be preferred.

Under typical operating conditions with V_a=250v, R_a=150 KΩ, Rg=150 KΩ, Rg_2=500 KΩ, R_k=1 KΩ, with the heater fed from a centre-tapped A.C. supply the equivalent hum voltage at the grid of an average grade A valve is approximately 5μV, whilst the combined noise (excluding hum generated by the valve and grid resistances, using a high quality A.F. amplifier) is not greater than 8μV.

The following table compares the noise, hum and microphony from the two grades of valve.

HUM
'A' × 5.6 down on 'B'

NOISE
'A' × 2 down on 'B'

MICROPHONY
'A' × 8 down on 'B'

SV3

THE EDISWAN MAZDA AC/SP3 RH is an indirectly heated Pentode with a special heater construction designed to reduce hum due to A.C. fields within the valve.
Provided precautions are taken to minimise hum due to external wiring, the AC/SP3 RH may be used in the early stages of amplifiers where the reduction of hum, noise and microphony is of primary importance.

Full technical information on request.

EDISWAN
MAZDA
VALVES & CATHODE RAY TUBES

The Edison Swan Electric Co. Ltd.
155 Charing Cross Road, London, W.C.2
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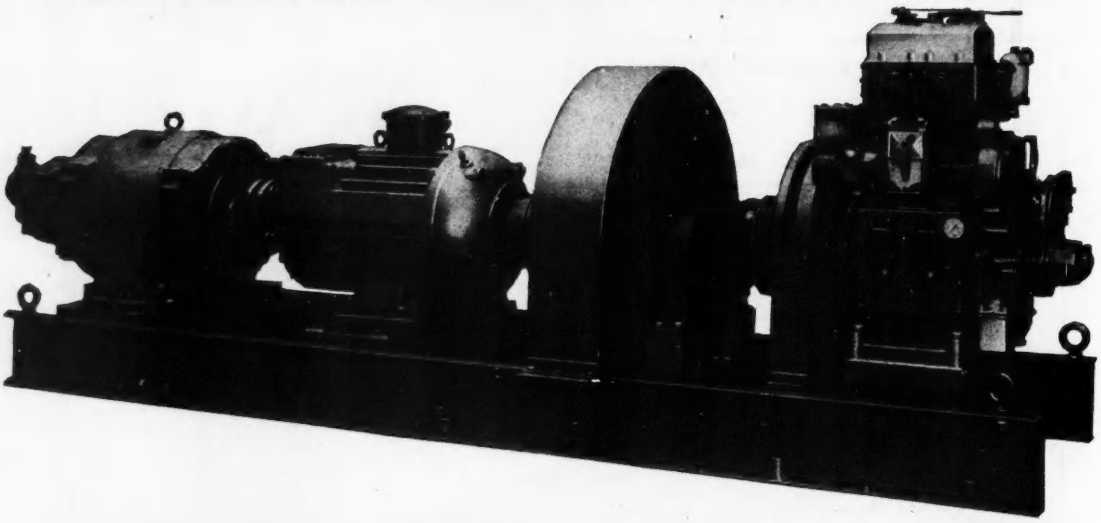

AUTOMATIC DIESEL GENERATING SETS FOR TELECOMMUNICATIONS SYSTEMS

Recent developments in modern Telecommunications Systems have emphasised the necessity for an unfailing and constant supply of Electric Power. Any failure of supply, even for a very short period, could have far-reaching and serious consequences to the users of the System. The selection of the most suitable diesel engines and control gear, therefore, becomes a matter of supreme importance. Pelapone engines over half a century have earned a reputation for unfailing reliability and are now being widely adopted for this purpose. Close liaison with the leading manufacturers of Telecommunications Systems has resulted in the development of a range of Generating Sets and Control Gear suitable for all modern Systems. Recent contracts on which Pelapone equipments are being used include a Canadian Micro-Wave System, an East African Radio Telephone Link, The Eire Trunk Carrier System, a Japanese Micro-Wave System; for a Malayan V.H.F. Communications System and in conjunction with telecommunications in Nigeria and South Africa.

PELAPONE ENGINES LIMITED

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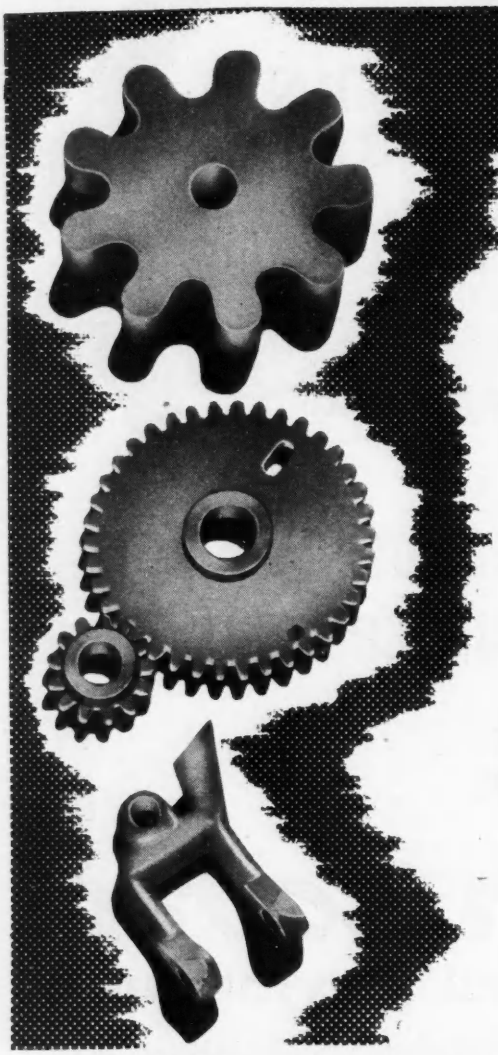

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M-W.387

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ACCURACY WITHIN YOUR GRASP

Designed for measurements of a very high order of accuracy, this VERNIER potentiometer is being used extensively for the accurate measurement of resistance, as a standard for calibrating potentiometers, meters and other electrical measuring instruments, for measuring thermo-couple voltages and for many applications of a similar nature. Through every stage of its manufacture the most careful precautions are taken to eliminate possible sources of error.

Please write for details of our range of precision potentiometers which also includes a SLIDE-WIRE type reading to 1 microvolt with an accuracy of .02% as well as a PORTABLE type which is completely self-contained, compact, robust and always ready for immediate use.

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WG.56

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Regulators similar to that illustrated above have been supplied to diverse industries in sizes ranging from 10 kVA to 400 kVA. In addition to which, many special types of regulators have been designed for building into customers' own equipment. Our specialist engineers would be glad to discuss your problems and perhaps show you where the efficiency of your plant can be improved by ensuring a "Steady Power Supply".

It pays to solve Voltage Problems before they happen!

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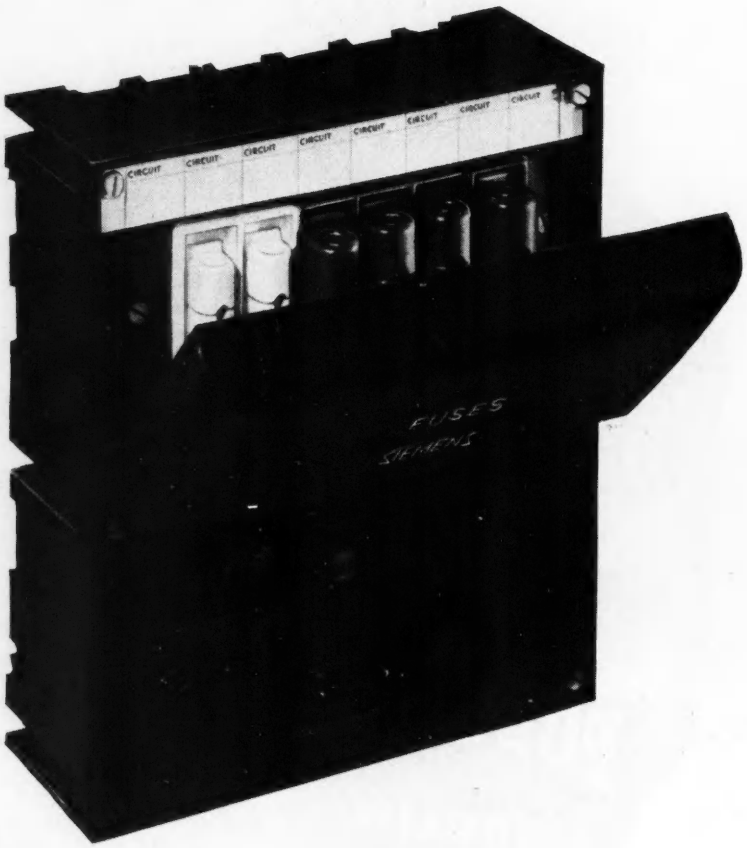
for such uses as this-only the special qualities of moulded plastics fulfil SIEMENS' exacting requirements . . .



Fuse box with hinged cover moulded from phenolic material for Siemens Brothers & Co. Ltd. This is only one of the many plastic components made at our Walthamstow factory for Messrs. Siemens.

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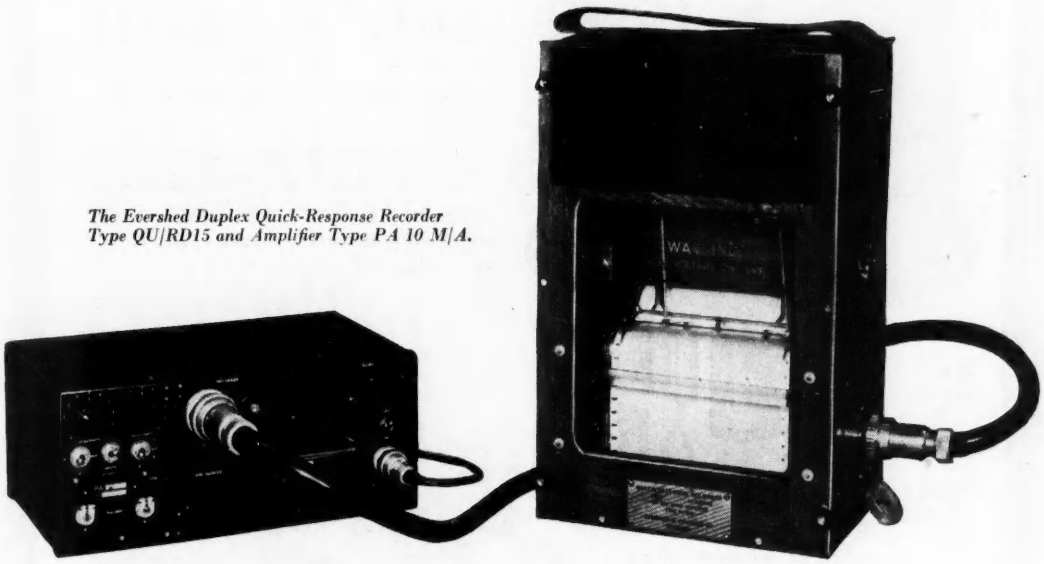

The Eversheд Duplex Quick-Response Recorder Type QU/RD15 and Amplifier Type PA 10 M/A.

The Evershed Quick Response Recorder is servo operated, and works in conjunction with an electronic amplifier. Recorder input is opposed by the feed back voltage from a resetting potentiometer controlled by position of the pen. The error (the voltage difference) drives the pen movement until the feed back voltage balances the input. Maximum sensitivity, with centre zero, plus/minus 4 volts full scale deflection.

The instrument will record sine wave voltages up to 15 cycles per second with amplitude error not exceeding 15% at a peak to peak amplitude of 1½ inches. At smaller amplitudes the frequency response will be higher.

Full details are given in Publication E.E. PL. 33

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SERIES 595 H

This is a hermetically sealed version of our series 595 Relay, which is already well known to the aircraft industry.

The armature design reduces the effects of shock, vibration and acceleration ; a spring type armature hinge eliminates backlash, friction and risk of displacement.

COIL: In all standard voltages up to 110 V. D.C. Working range between plus 10% and minus 20% of rating.

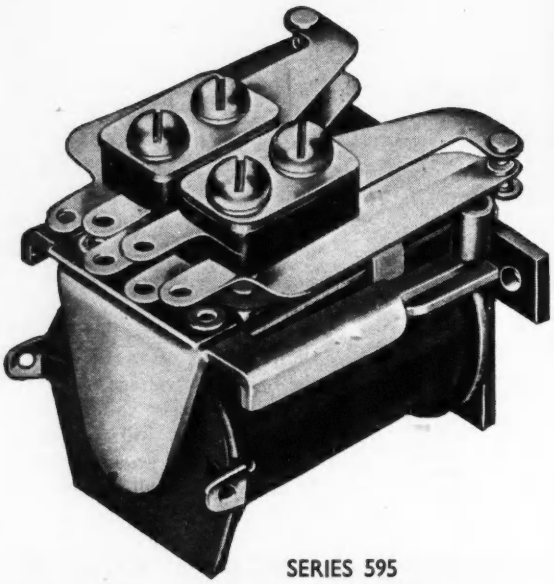
CONTACT COMBINATIONS: up to 2 pole changeover.

BASE: International octal.

WEIGHT: 3¼ ozs.

DIMENSIONS :

Diameter—1 11/16" overall.
Height —2 5/8" overall.



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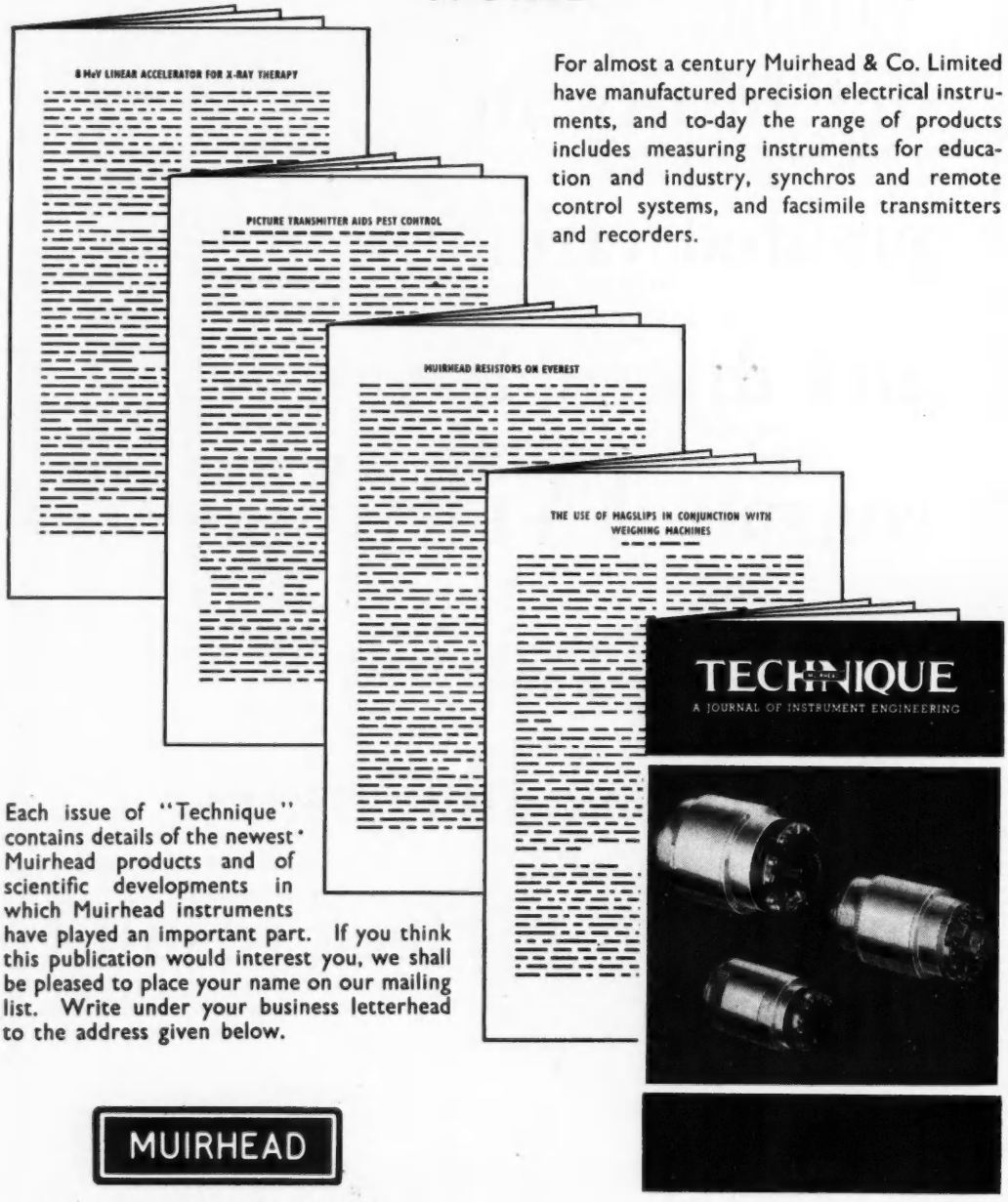
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THE USE OF MAGSLIPS IN CONJUNCTION WITH WEIGHING MACHINES
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MUIRHEAD

PRECISION ELECTRICAL INSTRUMENTS

133

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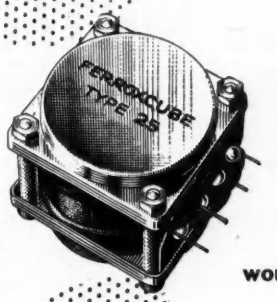

High Q inductance coils

wound on Ferroxcube cores

DESIGNERS of compact and efficient tuned circuits and wave filters are making ever-increasing use of Mullard high Q inductance coils.

Based on Ferroxcube, the world's most advanced magnetic core material, these coils combine small size with an inductance of up to 30 henries over a wide frequency range. Furthermore, their convenient shape and self screening properties facilitate either individual mounting or stacking.

Full details of these and other high grade components now available from Mullard will be gladly supplied on request.

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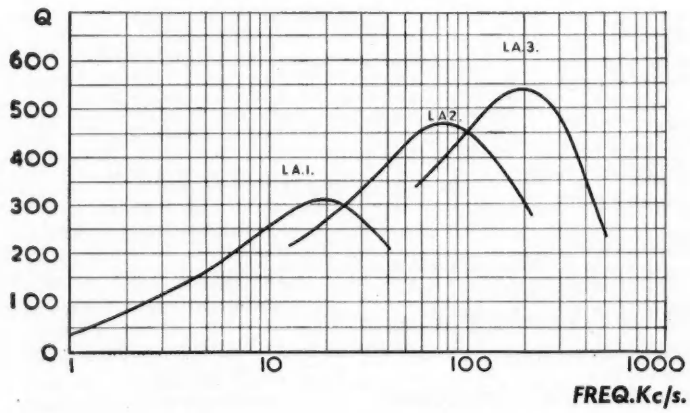

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Controllable air gap facilitating inductance adjustment

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— a precision instrument of outstanding performance

MODEL L.T.-1000-2S

- Reliability
- Exceptional accuracy
- Not affected by frequency
- Low distortion
- Fast response time
- No load to full load performance
- Excellent finish and fine workmanship throughout

Specification

RATING	1 KVA
INPUT VOLTAGE	190-260
INPUT FREQUENCY	50 c/s ± 10%
OUTPUT VOLTAGE	220-240 (adjustable)
REGULATION ACCURACY	±0.1% nom.
RECOVERY TIME	0.1 secs.
HARMONIC DISTORTION	3% nom.
P.F. RANGE	Unity to 0.7
LOAD RANGE	No load to full load

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ELECTRONIC INSTRUMENTS

DISTRIBUTED AMPLIFIER Type 2B

A high level wide band amplifier for use with high speed oscilloscopes, signal generators, etc.

Voltage Output—150 Vpp.
Bandwidth—100 Mc/s. *Gain*—x12.
Input Impedance—75 ohms. *Output Impedance*—200 ohms.

OSCILLOSCOPE Type WM.5

A new multi-purpose precision measuring oscilloscope.

NEW FEATURES: (a) The console model accommodates up to 6 plug-in sub units. This allows the basic oscilloscope to be adapted for a wide range of requirements; i.e. additional gain at high and low bandwidth, signal delay, comparison signals, T.V. picture and line selection, high voltage inputs, monitoring high impedance sources, etc.

(b) Continuously variable EHT1—10KV.
(c) 25 Mc/s bandwidth 'Y' Amplifiers.
(d) D.C. or A.C. coupled 'X' and 'Y' Amplifiers.
(e) Linear pre-sweep. A visual delaying sweep.

Time Range—10 milli-micro-seconds to 0.1 sec.
Voltage Range—10 mV to 500 V. AC/DC.
} Measurements by instantaneous metering system. No calibration markers required.

Photo Sweep—Single sweep for photo recording of transients, subsequent few sweeps before blackout of the tube give reference trace which can be pre-set to any D.C. voltage between 0 & ± 500V.

OSCILLOSCOPE Type WM.3B

A compact, general-purpose portable oscilloscope with facilities for making rapid precision measurements of time and voltage.

EHT—0.8—1.2KV. *Bandwidth*—D.C.—4.5 Mc/s.

Volts Range—10mV-500V. AC/DC.
Time Range—0.5 micro-seconds. — 40 milli-seconds.
} Measurements by instantaneous metering system. No calibration markers required.

Max. writing speed—0.5 micro-second/cm.

OSCILLOSCOPE Type WM.1

An inexpensive general-purpose miniature measuring oscilloscope.

EHT—800V. *Bandwidth*—1 Mc/s.—3 Mc/s.

Volts Range ± 0.5-500 volts. AC/DC.
} Measurements by instantaneous metering system. No calibration markers required.

Sweep Range—200 milli-seconds-10 micro-seconds (uncalibrated).
Sensitivity—1 cm/Volt.
Max. sweep speed—2 micro-seconds/cm.

The above instruments and other E.M.I. electronic equipment can be seen at the Exhibition of Scientific Instruments and Apparatus, Stand 88, New Horticultural Hall, Westminster, 25-28th April, 1955.

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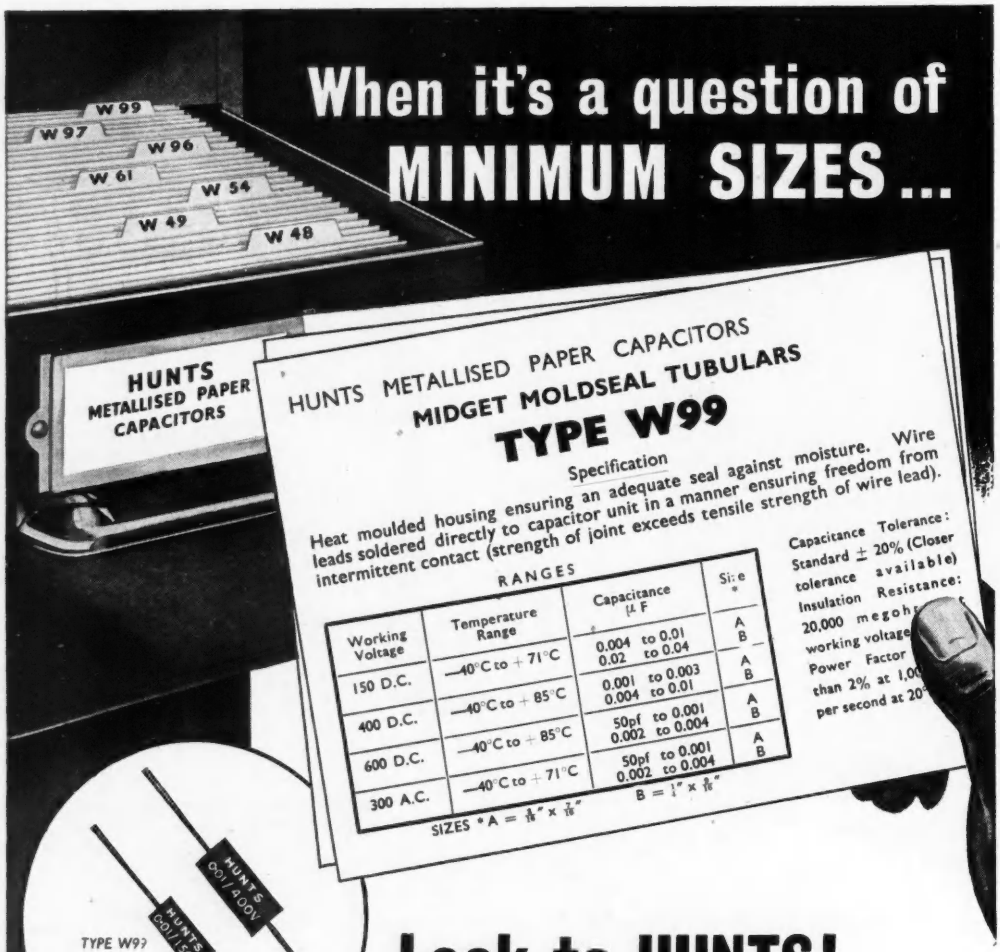
EF.41

When it's a question of MINIMUM SIZES...



Look to HUNTS!

For maximum reliability. Hunts capacitors for radio and electronic equipment include many types designed to meet the need of designers for decreased dimensions.

Type W99 listed above is just one example taken from Hunts unparalleled range of capacitors for every purpose.

Years of specialisation in nothing but capacitor design and manufacture has enabled us to achieve and maintain that long-lasting reliability, and outstanding performance which characterises every Hunt product.

Please write for leaflet giving full details of types for all applications.

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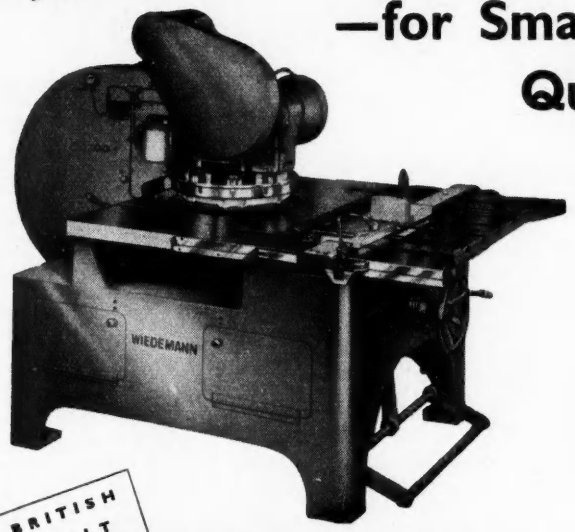
Fastest Piercing

—for Smaller Production Quantities



BRITISH BUILT

WIEDEMANN

Type RA-41P

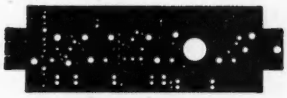
TURRET PUNCH PRESSES

give lower production costs
—than by any other method

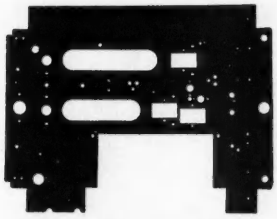
The RA-41P combines the versatility, accuracy and high speed of the pantograph for rapid hole location, with the time saving features of the WIEDEMANN Turret Punch Press for quick punch and die selection. Up to 20 low cost punches can be set up in the turret ready for instant use.

Maximum sheet size	28 in. x 40 in.
Throat depth	28 in.
Capacity	15 tons
Punching Capacity ...	3" diameter in .074" thick Mild Steel
	2" " " ½" " " "
	1 3/16" " " 7/16" " " "
Strokes per minute	175

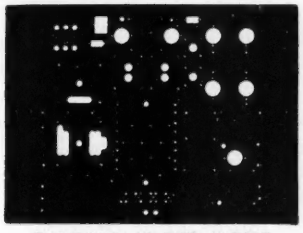
SHEET AREA UP TO 28" x 40"



OUTPUT—18 PER HOUR



OUTPUT—15 PER HOUR



OUTPUT—10 PER HOUR

ALL OPENINGS PIERCED IN TIMES SHOWN

The WIEDEMANN range includes small hand-operated models up to large power-operated machines of 80 tons capacity, capable of piercing 6" holes in ½" plate.

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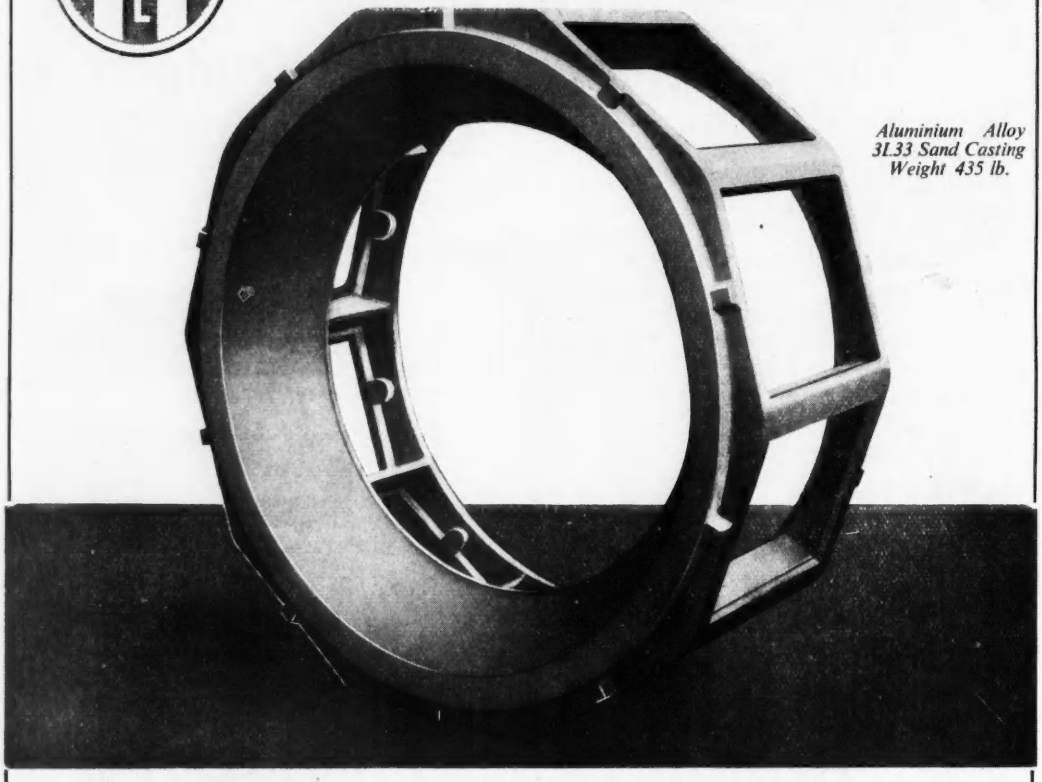

Aluminium Alloy 3L33 Sand Casting Weight 435 lb.

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Both our Foundries are available for Prototype Work.

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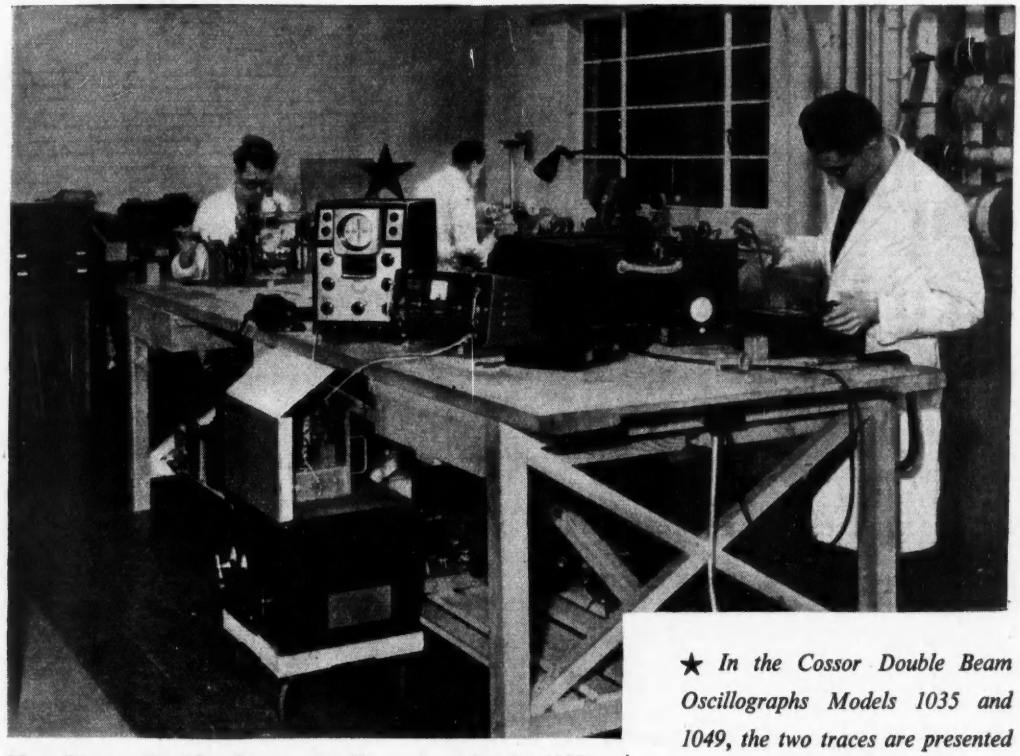

The Cossor Double Beam Oscillograph Model 1035 in use in the Research laboratories of Saunders-Roe Ltd., the famous flying boat manufacturers.

In displaying the mutual effect of two related and variable quantities simultaneously the Cossor Double Beam Oscillograph is solving many of the fundamental problems with which the Research and Development scientist is constantly beset. In the Production field, too, there are innumerable problems capable of complete solution by this versatile instrument and every branch of industry is realising the enormous potential of this apparatus in the detection and analysis of faults and the accurate monitoring of manufacturing processes.

The technical advisory staff of the Instrument Division is always at your service to help with your particular problem.

★ *In the Cossor Double Beam Oscillographs Models 1035 and 1049, the two traces are presented on a flat screen of 90 mm. dia., and the amplifiers are so calibrated that measurement of the voltage input as well as the time interval between various significant portions of the oscillogram is made possible. Permanent records for subsequent analysis may conveniently be made by attachment of Cossor Camera Model 1428, for which there is also a nine-speed Drive Unit Model 1431.*

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Please address enquiries to C1.68

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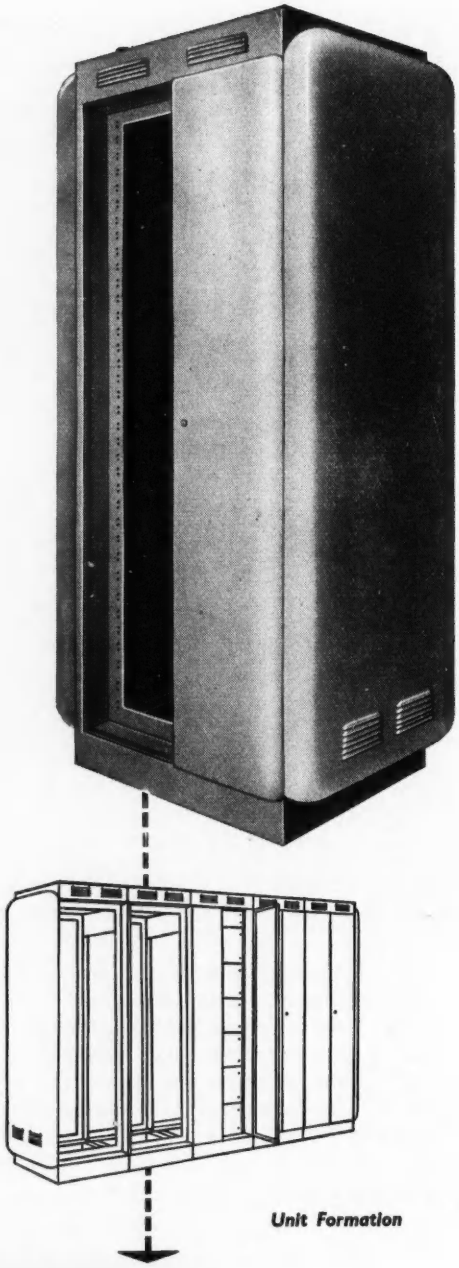

Unit Formation

Hassett & Harper Ltd

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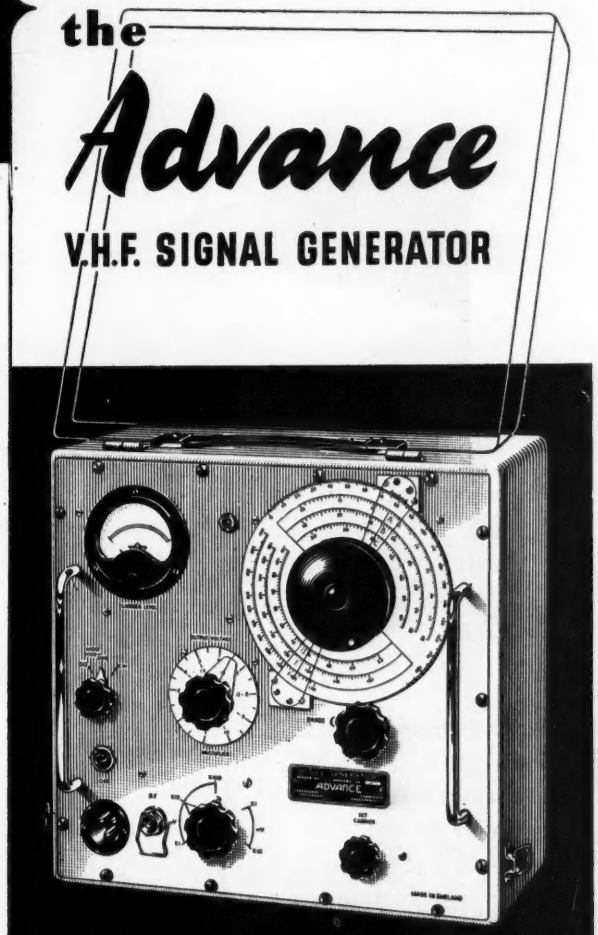
10 to 300 Mc/s DIRECTLY CALIBRATED

the **Advance** V.H.F. SIGNAL GENERATOR



The Advance D1 Signal Generator has long been recognised as supreme in its sphere for accuracy, ease of operation and reliability. Now comes the D1/D —an up-to-the-minute successor— possessing all those proven qualities, but plus the advantage of being DIRECTLY CALIBRATED. Whilst the range of the D1/D (10 to 300 Mc/s) is only slightly less than the original D1, its characteristics, given below, prove the " D " series to be the finest V.H.F. instruments available in their price class.

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- ***Max. attenuation error at 300 Mc/s plus/minus 4 db***
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- ***Light weight, only 34 lb.***

MODEL DI/D

Full Technical Details available in Folder M26

NETT PRICE IN U.K. **£97**

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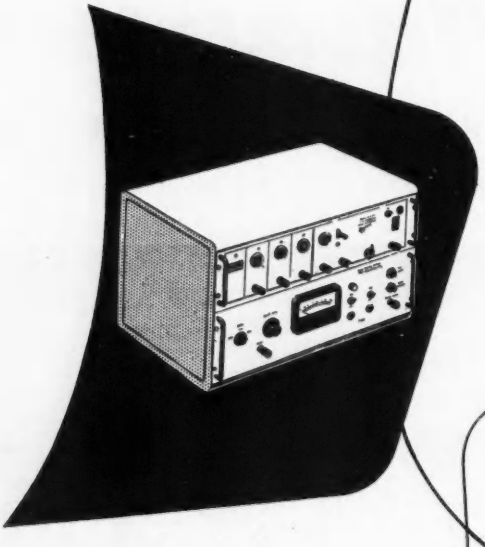
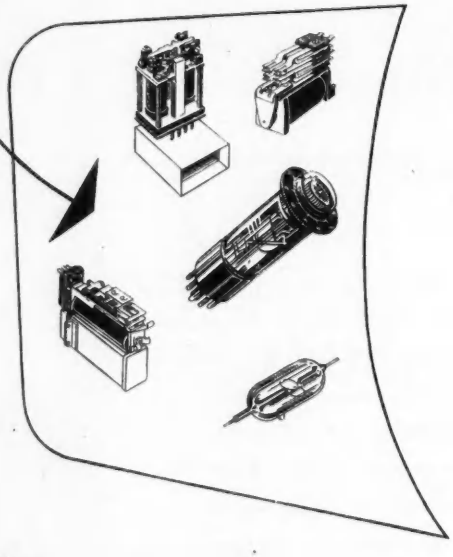


For 50 years we have enjoyed a high reputation for our standard of performance, reliability and finish in the communication field. We have now, in addition, brought this skill, experience and craftsmanship to the development and manufacture of a wide range of electronic and nucleonic instruments.



As originators of the Dekatron and other reliable cold cathode tubes and a variety of new electromechanical devices we feel that we are making a positive contribution to the Instrument field.

Consult us for all counting, scaling, timing and similar problems and components.

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E267

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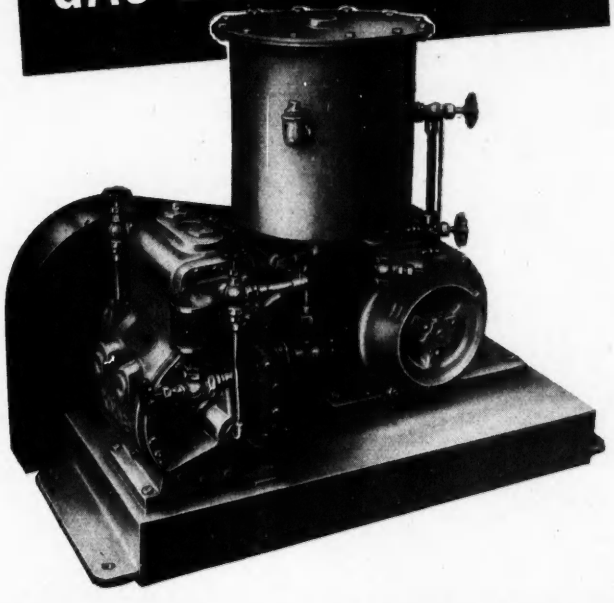

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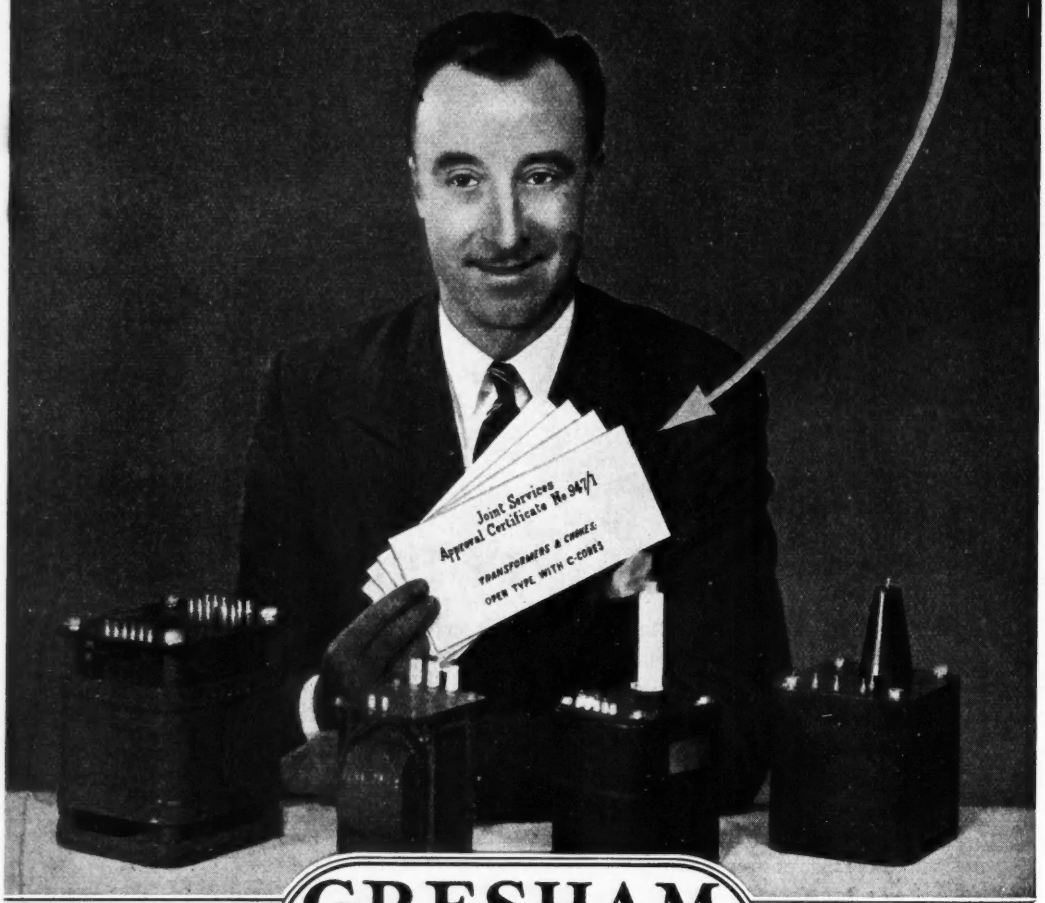

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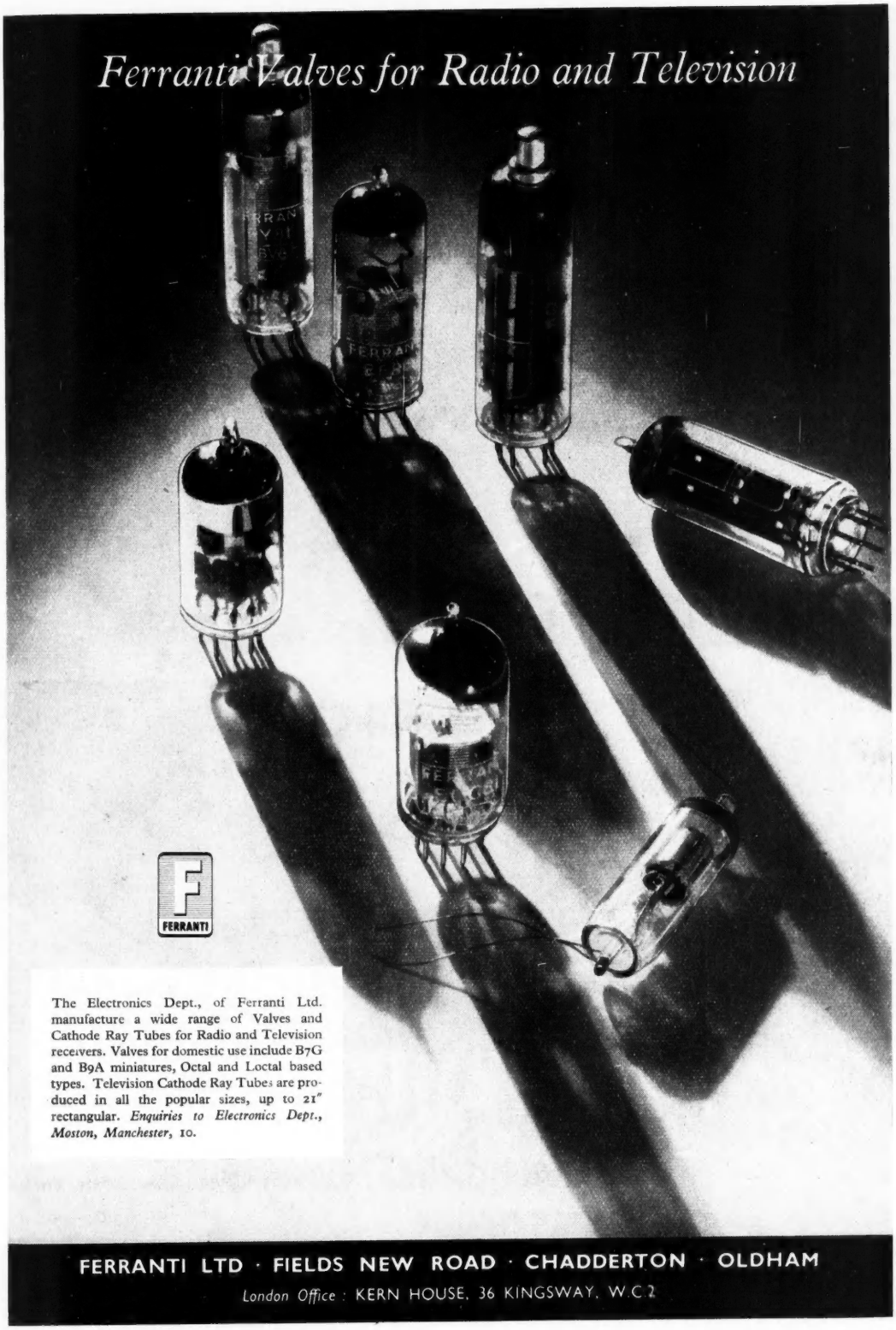

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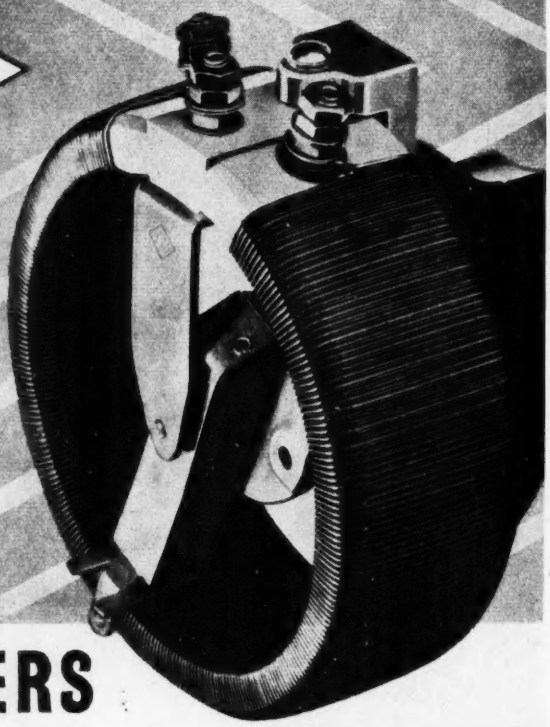

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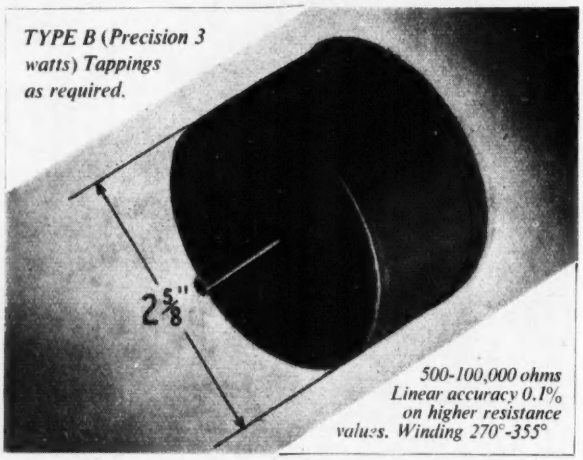

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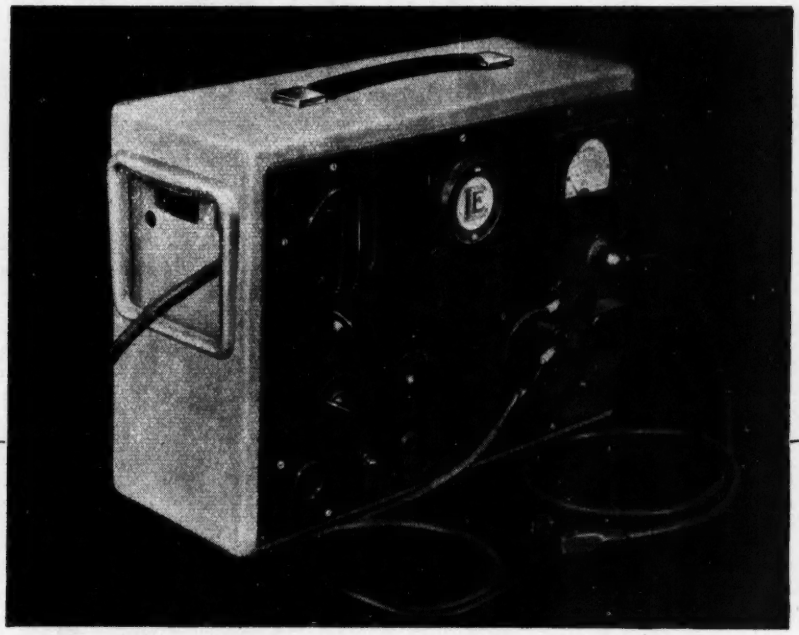

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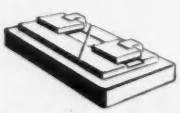

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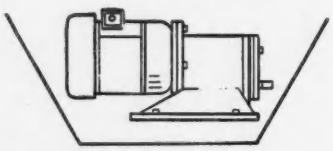

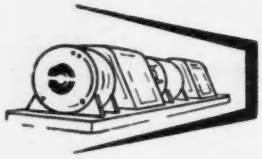

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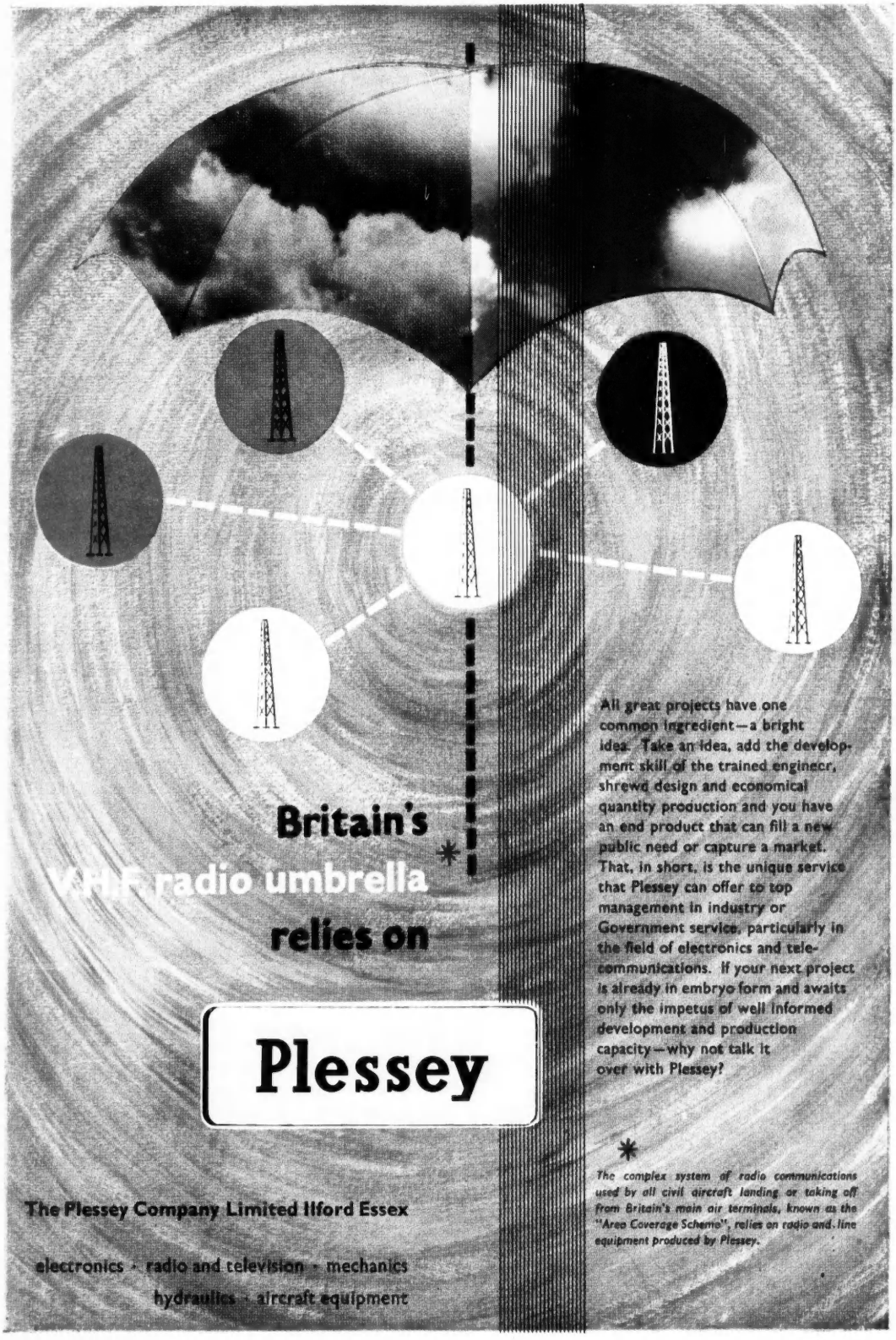
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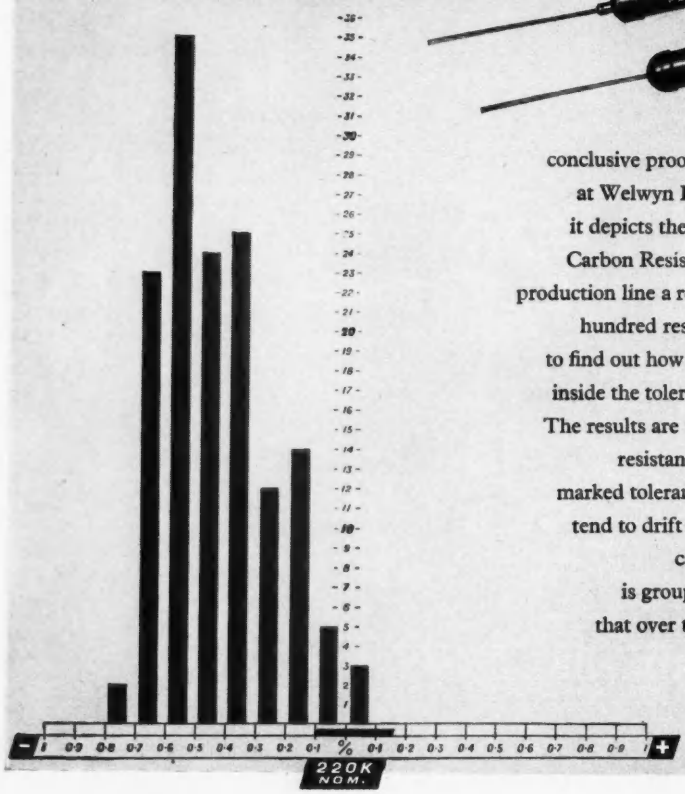

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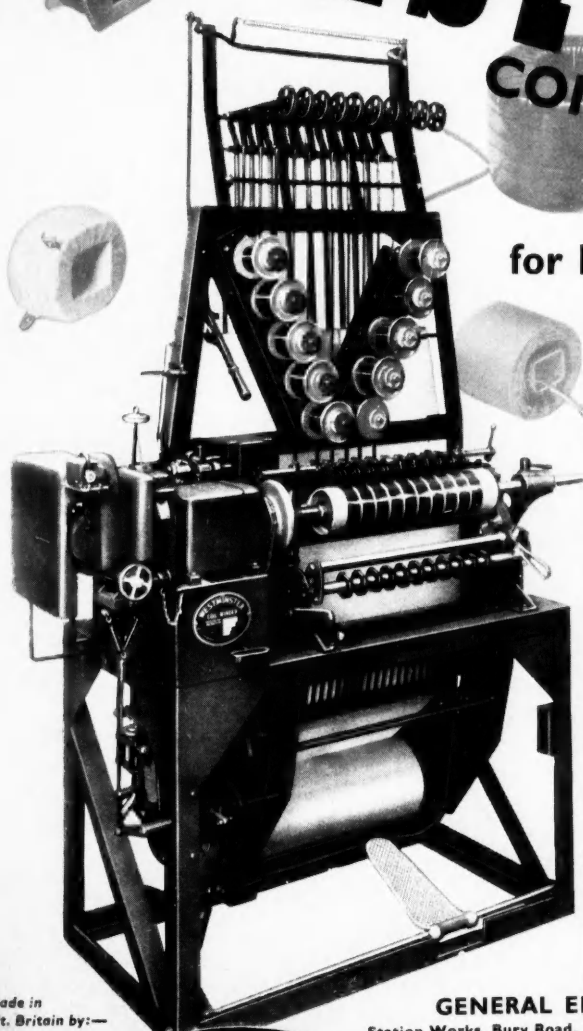

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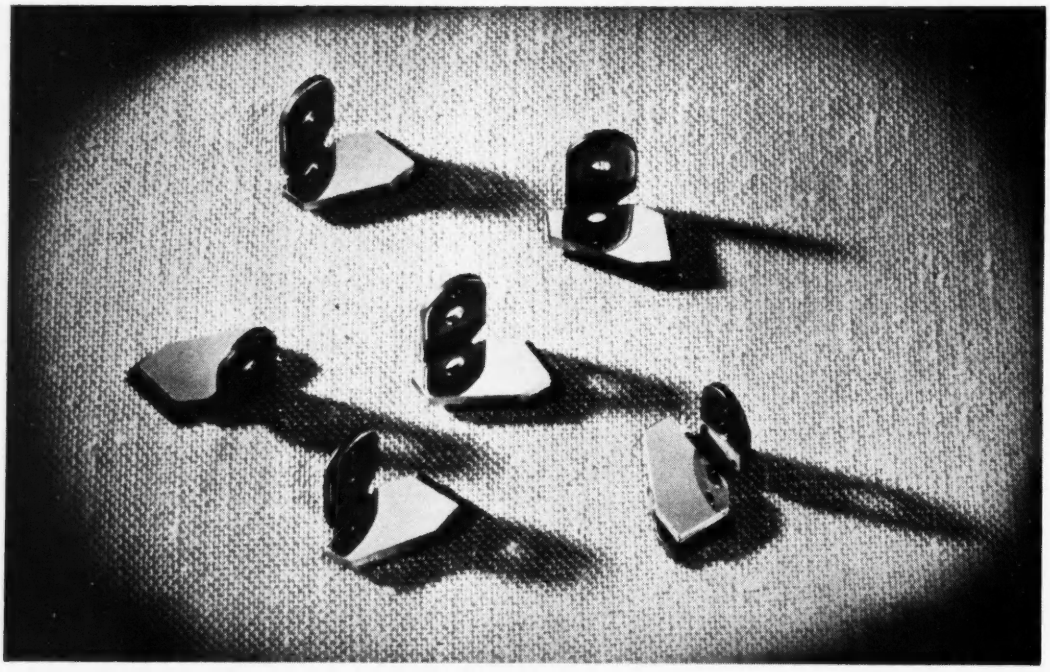

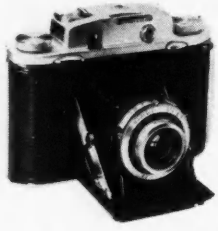

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Plate capacities	X	6 $\mu\mu$F
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Heater amps		1.0
VA_4 max. KV		20
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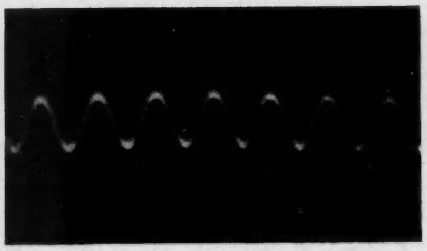

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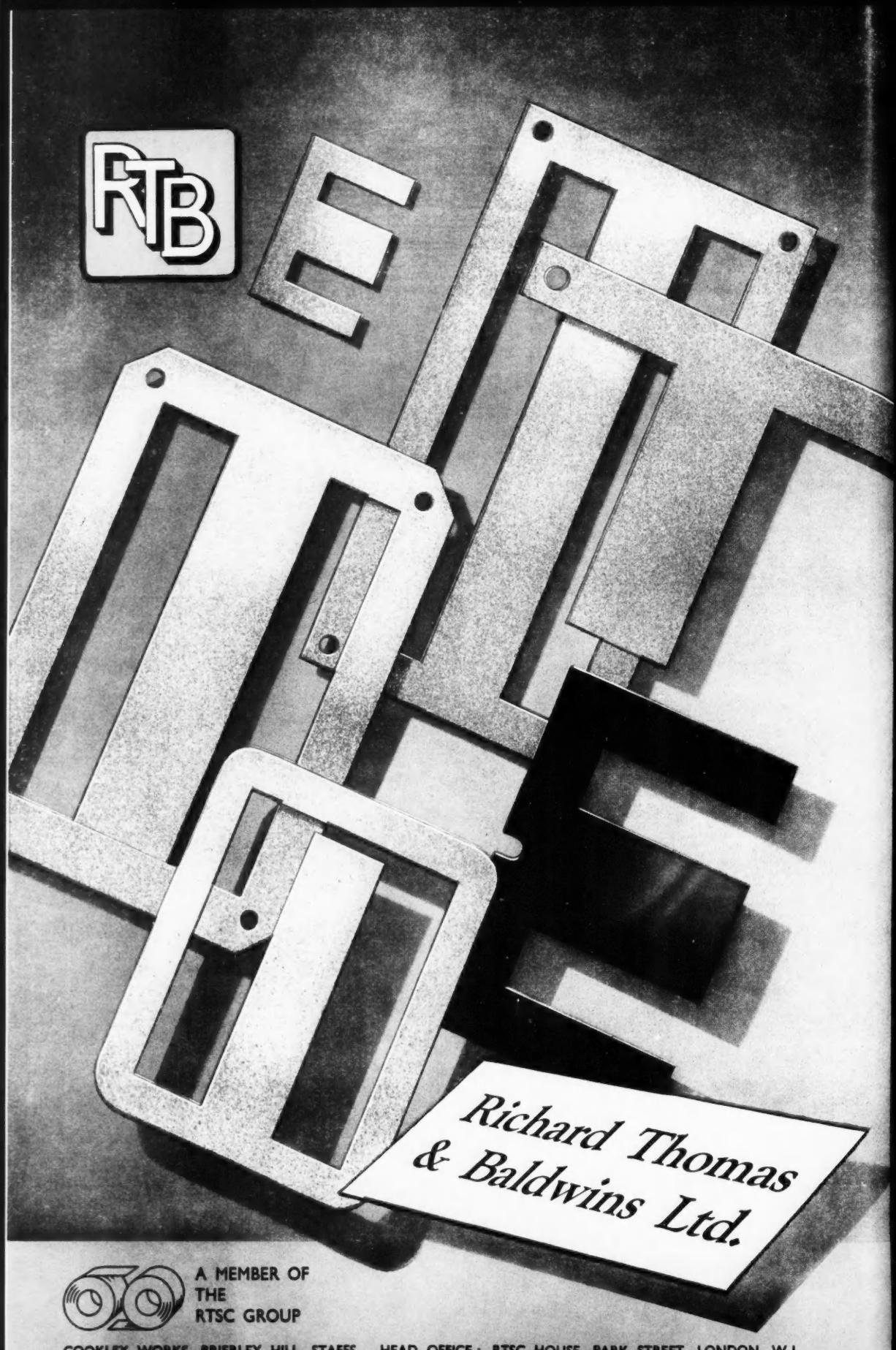

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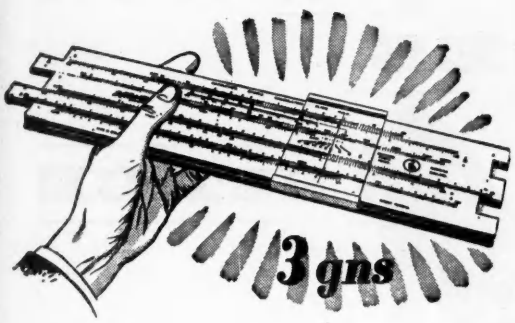

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Vol. 27 **MAY 1955** **No. 327**

Contents

Commentary	191
A Transient Pulse Width and Pulse Amplitude Meter — By F. Hart	192
Electronic Machine for Sorting Parcels	197
The Matrix Approach to Filters and Transmission Lines (Part 1) — By M. E. Fisher	198
A Reversible Binary Counter — By R. W. Fenemore	204
A Harmonic Response Plotter — By Z. Czajkowski	207
An Outline of An Electronic Arithmetic Unit — By W. Woods-Hill	212
The Display of Transformer Magnetizing Ampere-Turns on a Cathode-Ray Oscilloscope — By M. E. Bond	218
The Tapped Bridged-T Rejector — By D. J. S. Westwood	220
A Simple Quartz Crystal Oscillator Driven by a Junction Transistor — By H. G. Bassett	222
Colour Television Equipment	223
A New Circuit for Balancing the Characteristics of Pairs of Valves — By R. E. Aitchison	224
Notes from North America	227
The Physical Society's 39th Exhibition	228
Book Reviews	232
Letters to The Editor	234
Short News Items	236

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Classified Advertisements, Page 1
Index to ADVERTISERS, 141 and 142

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ELECTRONIC ENGINEERING

VOL. 27 No. 327

MAY 1955

Commentary

ASTRONOMY in Great Britain was probably at its zenith towards the end of the last century and its position was due in no small part to the early pioneering work done by the Earl of Rosse and Sir William Herschel in the construction of high power telescopes.

However, as the light gathering properties of the telescopes increased it became apparent that climatic conditions in this country were setting a limit to further progress and, as a result, the American continent, where the climate is more favourable, has been the principal centre for astronomy during the twentieth century.

Now, due to the enormous progress made during the Second World War in radar and radio techniques, an enormously powerful new tool known as radio astronomy is being placed in the hands of astronomers for the exploration of the space surrounding our planet, and one which, at the same time, bids fair to place this country in the position where it can pursue its studies of the universe without the handicap of fog and cloud.

Radio astronomy is of comparatively recent origin, for it was only in 1931 that an American engineer, Jansky, made the surprising discovery that radio waves were being generated in outer space and were capable of being received on earth. This discovery was published at the time but it created little interest among astronomers, although Grote Reber working in his garden at Illinois with apparatus of his own design was able to confirm Jansky's work.

Reber constructed what was, in fact, the first radio telescope and, pointing it to different parts in the sky, he was able to show that the radio signals were strongest from directions near the centre of the Milky Way, the strength of the signals being roughly proportional to the concentration of stars in the directions to which the telescope was pointing.

The war years brought work to a halt and no further progress was made until 1948 when the centre of interest had shifted to Sydney and Cambridge. By using many of the radar and radio techniques developed during the war it was discovered that at least some of the radio waves arriving from outer space were coming from discrete or localized sources which were called radio stars.

From 1948 onwards progress has been rapid, due principally to the great work carried out by A. C. B. Lovell, Professor of Radio Astronomy at the University of Manchester, on the radio telescope at Jodrell Bank in Cheshire. Much outstanding research was done with this telescope which, with its aperture of 220ft is still the largest in existence.

It had, however, certain limitations. It was fixed to the earth and only a small part of space could be explored. Experience with the instrument soon demonstrated that a completely steerable radio telescope of this order of size was essential for further exploration by this radio method.

At a recent lecture to the Royal Society of Arts Professor Lovell outlined some of the engineering difficulties associated with the construction of this giant telescope. With financial backing to the extent of approximately £500 000 provided by the Department of Scientific and Industrial Research and the Nuffield Foundation, the world's largest steerable radio telescope is now taking shape at the Jodrell Bank Experimental Station of the University of Manchester. It will have a parabaloidal reflector of 250ft aperture weighing some 500 tons and will be supported on towers rising 180ft from the ground.

The beam width of the telescope will be about 1° when used on a wavelength of one metre and its power gain will be over sixteen thousand, while on a wavelength of 21cm its beamwidth will be reduced to a few minutes of arc only.

This great discrimination and power gain will be used to elucidate the nature of the radio sources and to plot detailed maps of the sky, particularly in those regions which are obscured by interstellar dust.

During the last few years a great deal of attention has been given to a particular type of radio emission from space which is generated in the neutral hydrogen gas in the Milky Way on a wavelength of 21cm and great attention, therefore, will be attached to 21cm emissions when the telescope is in operation.

At the moment it seems likely that the importance of the problems associated with radio emissions from space will occupy nearly the whole time of the telescope for the first few years, but it is intended that it should be used to cover all aspects of radio astronomy, including those in which radio waves are first transmitted from the earth.

It is hoped that preliminary tests on the telescope in a fixed position will be made in the autumn of this year and that it will be in full operation by 1956.

At the present moment Britain has a lead of some four years in this new and fascinating subject of radio astronomy and, when the telescope is completed, studies of the universe and nearby space can once more be pursued in this country.

A Transient Pulse Width and Pulse Amplitude Meter

By F. Hart*, A.M.I.E.E.

The basic principle of measuring the amplitude of the transient is to charge a low leakage capacitor to the peak amplitude of the pulse and measure the voltage across the capacitor, with an electrometer type voltmeter, before the charge leaks away.

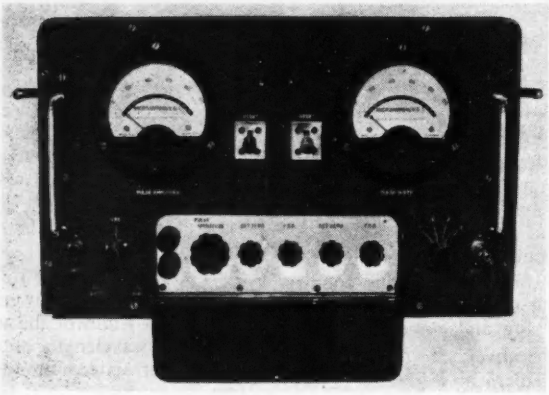
To measure the pulse width (at the base) a similar capacitor is allowed to charge linearly to an amplitude which is proportional to pulse width. The amplitude of the sawtooth thus produced is measured by a second electrometer voltmeter which gives a linear scale reading of pulse width.

STRAIN gauges, crystal pick-ups and other forms of transducer are used as electro-mechanical elements to produce pulses which correspond to the displacement, velocity or acceleration of a component under shock test.

The measurement of transient phenomena is normally accomplished by observing or photographing the waveform displayed on a c.r.t. There are many applications such as shock testing of structures, packages, electronic components, etc., in which the amplitude or duration of the impulse are the only quantities required. Where the work is purely repetitive, photography becomes laborious and uneconomical.

The instrument to be described was developed to read the peak amplitude of transient pulses originating from a valve under vibration. In the particular application for which the equipment was developed the combination of pulse amplitude and pulse width was of importance. The instrument therefore gives a meter indication of the peak amplitude and width of non-recurrent pulses.

Noise pulses originating in other components or assemblies, can also be measured.



The front panel of the pulse width-amplitude meter

Action

Pulse Amplitude

The input pulse should be positive and should have an amplitude greater than 0·5V and less than 10V.

If the transient to be measured has insufficient amplitude, any conventional amplifier, having a bandwidth suitable to pass the pulse without distortion, can be used to amplify the transient before feeding to the instrument.

Referring to Fig. 1, V_1 and V_4 constitute anode-followers having stable gains of approximately ten and unity respectively. The anode-follower type amplifier was used because of its ability to amplify a wide range of signal amplitudes without amplitude distortion. Fig. 2 shows the combined amplitude response of V_1 and V_4. The response is linear to inputs as great as 30V peak-to-peak.

Care should be taken with the layout and the quality of the components determining the gain of the amplifier. The resistors which determine the gain should have low self inductance and low capacitance. Capacitors should have no resistive or inductive components. The anode-follower is particularly susceptible to uncontrolled feedback circuits with subsequent modification of amplifier characteristics. With this in mind, the components should be spaced away from each other and the chassis.

Without the trimmer capacitor C_2 the high frequency response of the amplifier would be poor because of the h.f. filtering action of the resistor R_2 and the effective input capacitance of V_1.

Fig. 3(b) shows the response of V_1 to the 10μsec input square wave shown in Fig. 3(a).

Fig. 3(c) shows the square wave response of the two amplifiers.

Examination of Fig. 3(c) shows that the amplifier rise time-constant is approximately 1μsec.

The input positive-going transient, after linear amplification, by V_1 and V_4, is fed through the cathode-follower V_5 to the charging capacitor C_{18}. As the output pulse from the cathode-follower builds up positively, the diode V_{5b} conducts, keeping the right-hand plate of the charging capacitor slightly above earth potential. When the pulse has reached peak amplitude, the diode stops conducting and leaves a charge in the capacitor proportional to the pulse amplitude. Fig. 3(d) shows the response of the charging capacitor to a single impulse input.

To obtain a true representation of the capacitor charge, it is not sufficient to observe the waveform at the cathode of the cathode-follower since the resistance of the conducting diode must be considered as part of the charging source. We require the time to charge the capacitor from a source impedance consisting of the cathode-follower in series with

* *Ministry of Supply.*

the conducting diode. To achieve this, the capacitor and the diode were interchanged and the oscilloscope was connected across the capacitor with one terminal at earth potential. To simulate single impulse conditions, while keeping a reasonable c.r.t. brightness for photographic purposes, the "reset" switch was shunted with a 47kΩ resistor to allow the capacitor to discharge completely between impulses of low p.r.f.

From the photographs it will be seen that the value of the charging capacitor determines the minimum width of pulse that can be measured without amplitude distortion.

right-hand plate of the 0·01μF capacitor charged to a negative potential proportional to the amplitude of the input pulse. This negative potential is measured by the cathode-follower electrometer valve V_{10}. To maintain a high input resistance, the heater voltage is limited to 4·3V and the anode to 90V. A typical graph showing the relationship between the negative potential applied to the grid of electrometer valve and the output meter reading is shown in Fig. 5. It will be seen that the circuit is quite linear over the specified range of input voltages.

Fig. 6 shows the amplitude response of the cathode-

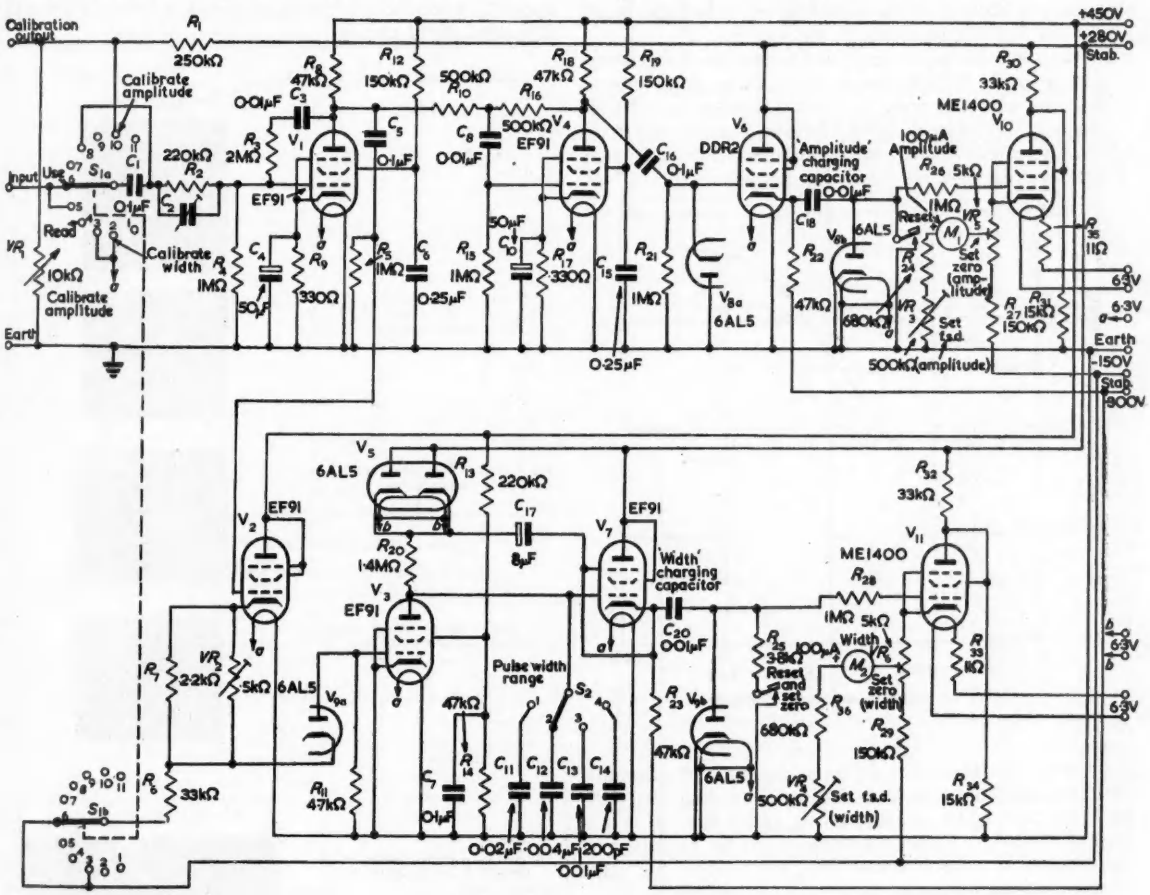


Fig. 1. The pulse width-amplitude meter

It will be seen from Fig. 3(d) that the charge time-constant is approximately 3μsec. Thus a pulse of 12μsec would rise to 98 per cent of the maximum value and a pulse of 15μsec to 99·3 per cent. The measured relationship between the pulse amplitude meter reading and a constant amplitude single impulse of varying width is shown in Fig. 4. It will be seen that amplitude limiting occurs on pulses of less than 15μsec width.

During the pulse the left-hand plate of the charging capacitor C_{18} stays at a positive potential proportional to the incoming pulse amplitude. At the end of the pulse the left-hand plate of the capacitor starts to fall and the right-hand plate of the capacitor falls by an amount equal to the positive potential which existed on the left-hand plate. Thus at the cessation of the pulse we are left with the follower V_6, to a positive potential. Here again the amplification is linear to inputs up to +200V. With sufficient input to give full scale deflexion on the output meter, there is still an effective bias of 5V on the cathode-follower which precludes the passing of grid current.

It will have been observed that the amplifier has a better frequency response than the cathode-follower and grid current will be taken by the cathode-follower V_6 during a fast rising input pulse. However, the effective output impedance of V_4 is approximately 500Ω, so that amplitude limiting can be neglected.

At the end of the pulse the 0·01μF capacitor C_{18} starts to discharge through any available leakage paths. The main leakage paths available are:

(1) The insulation resistance of the capacitor C_{18}—greater than $20 \times 10^6 M\Omega$.

(2) The ME1400 effective input resistance—greater than $2 \times 10^6 M\Omega$.

(3) The CV140 (6AL5) p.t.f.e. valve holder—greater than $2 \times 10^6 M\Omega$.

(4) The CV140 (6AL5) valve total leakage between anode and earth—greater than $0{\cdot}5 \times 10^6 M\Omega$.

It will be seen that the limiting component tending to reduce the leakage time-constant is the CV140 valve so that there is nothing to be gained by excluding the diode holder and holding the diode in the wiring.

In like applications the insulation resistance of capacitors is invariably the limiting factor determining circuit operability. The capacitor used in this application is a T.C.C. Plastapack polystyrene film dielectric type which is admirably suited, having such a high insulation resistance. The measured effective discharge time-constant of 100

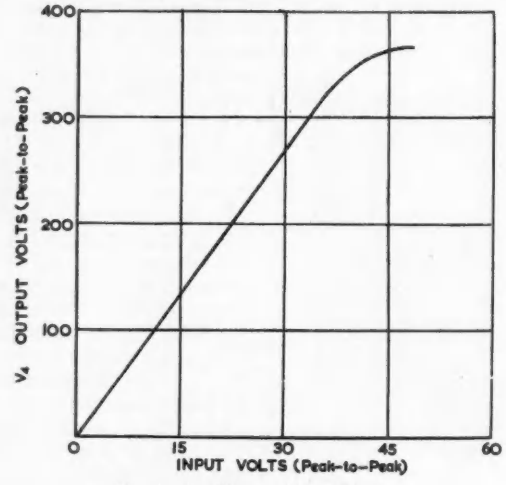


Fig. 2. Amplifier amplitude distortion
Input frequency—500c/s; h.t.—450V; gain—×9.

minutes is such that when an input transient of amplitude 10V has registered full scale, the meter reading then falls by 1 per cent in 50 seconds, giving ample time to take a reading. Pulses narrower than 15μsec can be measured, at the expense of a faster decay time, by reducing the value of the charging capacitor C_{18}.

To reset the meter after taking a reading a non-locking discharge switch (S_3) is operated to discharge the capacitor. To reduce the leakage paths the switch consists of a phosphor bronze spring strip which is remotely controlled by a Bowden cable. The charging capacitor carries no switch contact or associated leakage paths, the phosphor bronze strip simply wiping across the capacitor terminal to effect a discharge.

Pulse Width

To measure the transient pulse width, the input pulse, having been phase inverted in V_1, is fed through the cathode-follower V_2 to the pentode V_3. This valve, normally conducting, has a fixed anode current of 200μA determined by the high stability anode load of 1·4MΩ in series with the conducting diode V_5 and the stabilized supply voltage of +280V. When the control grid of V_3 is cut off the capacitor C_{12} starts to charge through the 1·4MΩ resistor. This rising potential is fed via the cathode-follower V_7 to the high potential end of the anode load resistor. This raises the potential on the cathode of the diode V_5 above +280V and the diode ceases to conduct. Assuming that the cathode-follower was perfect, the high potential end of the charging resistor would now follow exactly the rise in potential across the capacitor C_{12}. This means that the steady current of 200μA which was flowing through the valve would now be supplied from the cathode-follower, through the 8μF capacitor C_{17} and into the capacitor C_{12} since the diode and pentode are both cut off and virtually out of circuit.

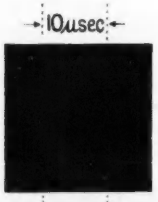


Fig. 3(a). Input pulse

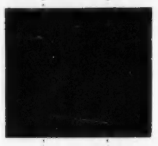


Fig. 3(b). Response of V_1 to input pulse

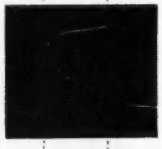


Fig. 3(c). Response of V_4 to input pulse

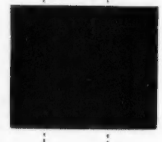


Fig. 3(d). Response of charging capacitor C_{18}

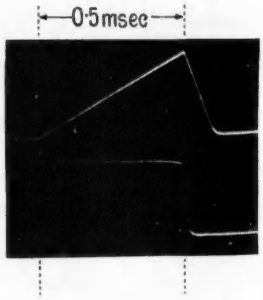


Fig. 3(e). Linear charge of C_{12} due to 0·5msec input pulse

Assuming the cathode-follower gain were unity the current (i) flowing into the capacitor C_{12} would be constant and hence the voltage rise (V_c) would be linear governed by the expression:

$$V_c = it/C_{12} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

The cathode-follower gain is slightly less than unity and the expression (1) for the voltage across the capacitor is

given by:

$$V_c = \frac{V_{ht}}{1 - G}[1 - \exp(-t)(1 - G)/C_{12}R] \ldots\ldots (2)$$

where G is the gain of the cathode-follower.

$$G = \frac{\mu R_k}{r_a + (\mu + 1)R_k} \ldots\ldots\ldots\ldots (3)$$

So, making R_k large so that $(\mu + 1)R_k > r_a$

$$G \simeq \frac{\mu}{\mu + 1}$$

i.e. $1 - G \simeq 1/\mu$.

Referring to equation (2) the capacitor appears to be

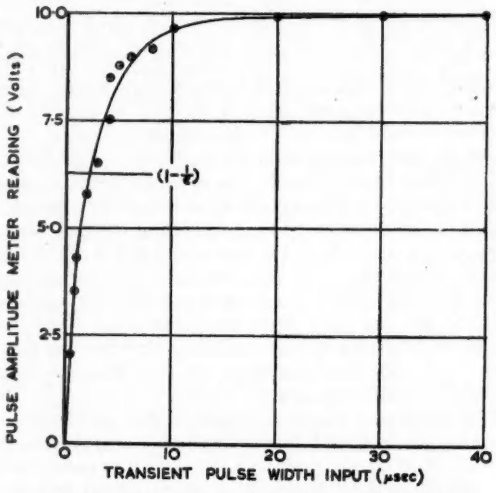


Fig. 4. Pulse response of transient amplitude meter
Constant amplitude input pulse of 10V; effective CR approximately 2·4μsec.

charging on a time-constant of $\mu C_{12}R$ from a potential of μ times the h.t. voltage.

There are four ranges for pulse width as shown in Table 1.

TABLE 1

RANGE	SCALE MULTIPLIER	CHARGING CAPACITOR
10—100 μsec	0.1	200 pF*
50—500 μsec	0.5	·001 μF ± 1% h.s.
0·2—2 msec	2	·004 μF ± 1% h.s.
1—10 msec	10	0·02 μF ± 1% h.s.

** This capacitor comprises a 170pF ± 5% h.s. in parallel with a trimmer which is adjusted so that the total capacitance, including strays, is 200pF.*

Considering the 10msec range and assuming perfect linearity of charge, substituting in equation (1) it will be seen that full scale deflexion is reached when $V_c = 100V$.

Substituting in equation (2) $R = 1{\cdot}4M\Omega$

$$C_{12} = 0{\cdot}02\mu F$$

$$\mu = 35$$

$$V_{ht} = 280V$$

we find that $V_c = 99{\cdot}5V$, giving a theoretical loss of linearity of $-0{\cdot}5$ per cent.

Fig. 3(e) shows the linear charge of the capacitor C_{12} to an input pulse of 0·5msec width.

When the input pulse falls to zero, the pentode V_3 again conducts and the capacitor C_{12} is discharged nearly to earth potential. The potential of the cathode of V_7 and hence of the 8μF capacitor also fall; the diode V_5 conducts and the 8μF capacitor is supplied with the small amount of charge lost due to charging the capacitor C_{12}. Thus the circuit returns to its original state ready for the next transient.

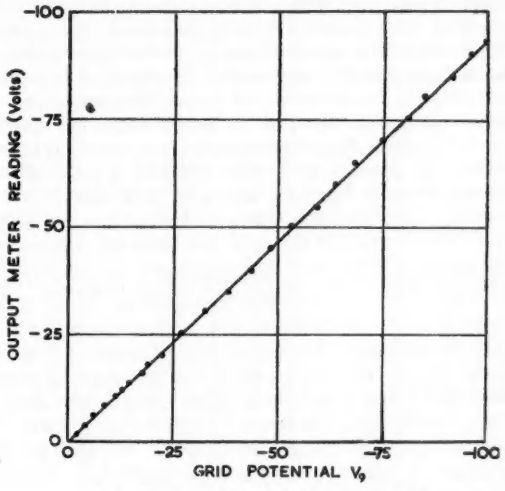


Fig. 5. Electrometer cathode-follower linearity

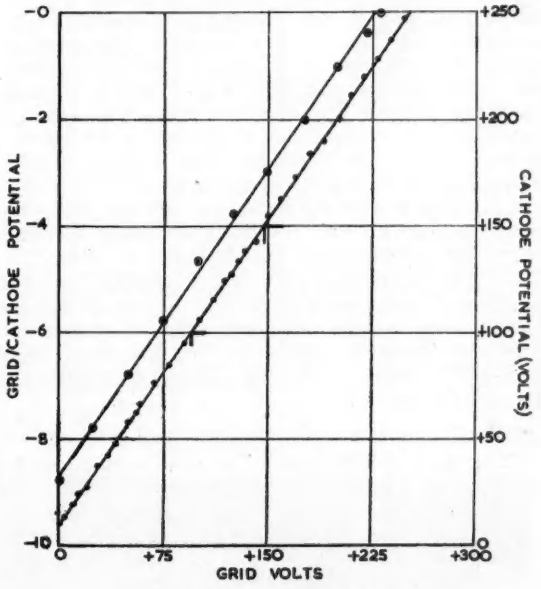


Fig. 6. V_5 d.c. characteristics

It will be seen that capacitor C_{17} must be large compared with C_{12} to keep the change of potential across R_{20} to a minimum and preserve the linearity of the charge.

The operation of the remainder of the circuit is similar to the pulse amplitude circuit except that the "Width" charging capacitor C_{20} is negatively charged to the peak value of a sawtooth instead of an exponential waveform. It is obvious that the linear increase of potential across C_{12} is directly proportional to the applied pulse width giving a linear scale meter reading.

Calibration

Set Zero—Pulse Amplitude and Pulse Width

To set the zero meter reading in both the pulse amplitude and width meters, the "set zero" non-locking switches are closed and the "set zero" potentiometers adjusted until the meters read zero. When the switches are released it will be noticed that the meters read approximately one per cent of f.s.d. This effect is mainly due to diode contact potential. This false zero is the more correct setting since a positive input pulse to the diode having an amplitude equal to the contact potential, say 1 volt, would cause no current to flow into the charging capacitor, but the meter would still indicate correctly at 1 volt. Similarly a pulse of, say, 70V would cause charging current to flow due to 69V of the pulse. The false zero setting thus compensates for contact potential error. In any case the diode input pulses are high compared with contact potential, so that the resultant percentage error is very small and can be neglected.

Set Full Scale Deflexion—Pulse Amplitude

Any d.c. voltmeter of known calibration accuracy is connected, and remains connected during the pulse amplitude calibration, to the terminals labelled "calibration output".

The "calibrate amplitude" potentiometer VR_1 is adjusted until the voltage, as read on the external d.c. voltmeter, is 10V. To set f.s.d. the calibration switch is simply turned to "calibrate amplitude". A d.c. potential of 10V is thus passed to the input of the amplifier producing an amplified transient to the cathode-follower V_6, causing the meter to read. The set f.s.d. potentiometer is then adjusted to give full scale reading on the meter. To repeat, the calibration switch is rotated anti-clockwise to the "use" position and again turned to the "calibrate amplitude" position to re-check the calibration. The input capacitor C_1 is automatically discharged as the switch is returned to the "use" position. This is necessary otherwise the capacitor would only discharge slowly through its own leakage resistance, giving an effective calibration signal of much less than 10V due to the charge remaining in the input capacitor C_1.

To check other points on the meter scale the "calibrate amplitude" potentiometer is adjusted to read the required input voltage and the calibration switch is rotated from "use" to "calibrate amplitude" and the output meter indication is checked against the steady voltage reading on the external voltmeter.

Set Full Scale Deflexion—Pulse Width

To set the f.s.d. calibration of the pulse width meter, first turn the pulse width range switch to the 10msec range (position 1, $C_{11} = 0{\cdot}02\mu F$). Next turn the calibration switch from "use" to "calibrate width". During the time that the switches are in position 3 a 50c/s sine wave of approximately 180V peak-to-peak appears on the cathode of V_2. The diode V_{9a} conducts on the negative half cycles so that the pentode is cut off for 10msec, allowing the capacitor C_{11} to charge to 100V. The pulse width meter reading can now be adjusted to read full scale. The calibration on the other ranges will now be correct assuming that the high stability capacitors C_{12} to C_{14} have been chosen to suit the scale ranges required.

Further detail is appropriate at this stage. Referring to the switch contacts S_{1b}, it will be seen that when on the "calibrate width" position the -150V supply is not being supplied to V_2. Had the switch been left in position 3 the capacitor C_{20} would carry the 50c/s sawtooth component found at the anode of V_3 in addition to the peak d.c. component and the meter would read the mean value which would have a form factor of approximately $\frac{1}{2}$ for an equal mark-space sawtooth. Thus, as the switch is rotated from the "use" to "calibrate width" position, so long as the switch remains on position 3 for more than 0·02sec, at least one half-cycle of the 50c/s calibration signal will pass to V_3. The capacitor C_{20} will then be fully charged to the peak value of the sawtooth and the a.c. component will be automatically removed when the switch reaches the "calibrate width" position (position 2). To remove the a.c. component, it was found better to disconnect the negative supply to V_2 rather than switch off the input calibration signal. Switching off at the input produces sudden discontinuities giving an erroneous calibration. If the supply to V_2 is switched off, the calibration signal simply falls to zero without any discontinuity. With this in mind the switch S_{1a} has make before break contacts to ensure that the input signal is not momentarily switched off when moving from one contact to another.

During the quiescent state in the "use" condition it is essential that the diode V_{9a} be non-conducting. If the cathode potential of this diode were negative, V_3 would be permanently cut off, C_{12} would be fully charged and the meter would not indicate on subsequent pulses. To achieve this, the current through the cathode-follower V_2 is stabilized by the 33kΩ h.s. resistor and the stabilized -150V supply so that the diode cathode potential can be set at, say, 2V positive ensuring that the diode is not conducting. This means that V_3 will not be cut off until the negative half-cycle input to V_2 has moved through about 3V. The 90V negative half-cycle calibration signal would give an angle of "no flow" of 176°. Thus there is an inherent error of $+2{\cdot}2$ per cent when measuring the width of pulses having very fast rise and fall times. It has already been shown that there already exists a $-0{\cdot}5$ per cent error in the amplitude of the sawtooth waveform. The resultant error is small enough to be neglected. Furthermore, there is an advantage in using such a conservative bias of $+2$V on the cathode of the diode V_{9a}. Without this amplitude discrimination unwanted hum signals which are fed to the input will be amplified by V_1 and tend to cut off V_3 and give full scale readings, particularly on the narrower width ranges. With this in mind the potentiometer VR_2 has been included in the cathode circuit of V_2. The diode bias can now be adjusted to eliminate the effect of extraneous input hum signals. Similarly unwanted noise signals can be rejected.

Stable supplies and components are not essential in most parts of the circuit since the built-in calibration facilities permit easy setting up. With the circuit as shown continuous re-calibration due to mains and component variation is reduced giving a calibration accuracy of approximately ± 3 per cent.

Subsidiary Uses

Frequency Meter

It will be understood from the action of the 50c/s calibration signal producing full scale deflexion on the 10msec range that the same principle applies on the other ranges at different frequencies. Thus, sine waves at frequencies other than 50c/s and having amplitude of 6·3V r.m.s. would also cut off V_3 for the same fraction (176/360) of a cycle. Therefore, if the meter is set to read f.s.d. on 50c/s there will be no errors on the other ranges at higher frequencies.

The operation would be to apply the signal, having a peak amplitude of less than 10V, to the input terminal,

then switch from "use" to "read" and the meter reading would then indicate the input frequency, e.g. on the 2msec to 0·2msec range a 500c/s sine wave applied to the input would read half full scale when switched to the "read" position.

The ranges of frequency measurements corresponding to the pulse width ranges are shown in Table 2.

TABLE 2

PULSE WIDTH RANGE	FREQUENCY COVERAGE
10—1msec	50—500c/s.
2—0·2msec	250—2500c/s.
500—50μsec	1—10kc/s.
100—10μsec	5—50kc/s.

For small input amplitude the angle of no flow decreases, giving a negative error in the indication. However, measurements on the instrument give negligible errors so long as the input does not drop below 1·5V r.m.s.

PEAK-TO-PEAK VOLTMETER

Repetitive signals applied to the input become negative with respect to earth by action of the diode V_{8b} On disconnecting the input by switching to "read", the a.c. component across C_{18} disappears, leaving the peak-to-peak voltage of the input signal across C_{18}, i.e. 1 to 3 mark-space positive square wave (mean/peak = $\frac{1}{4}$) of amplitude 10V, applied to the input which would be restored negatively by the diode V_{8b} to give a mean/peak ratio of $\frac{1}{4}$ and a meter reading of 7·5V. If the input is switched off, the meter would then read the true peak value of 10V.

The diode V_{8a}, although not essential when measuring transient pulses, is included to restore recurrent signals positively with respect to earth. This ensures that the pulses into the cathode-follower V_6 always start their positive excursion from the same fixed potential. Without the diode the meter reading would increase as the p.r.f. is reduced.

With recurrent pulses the charging capacitor C_{18} is fully charged during the first pulse so that the high frequency response to subsequent pulses is improved. With this particular amplifier the minimum width of a recurrent pulse which can be measured is 3μsec as compared with 15μsec for a transient pulse.

For a sine wave input the negative restoration by the diode V_{8b} produces a mean/peak-to-peak ratio of 2/1 and the meter reads half the peak-to-peak value of any particular input. On switching off the input the meter reading is doubled to give the true peak-to-peak value.

INTERVAL TIMER

If the interval to be measured is in the form of a positive square wave, intervals between 10μsec and 10msec can obviously be measured. If the interval is not available in this form it is generally a simple matter to produce a positive square wave from the "start" and "stop" pulses or the "make" and "break" contacts of the particular item under test.

Acknowledgments

Assistance received from members of the I.E.M.E. staff is appreciated by the author.

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this article. Reproduced with the permission of the Controller of H.M. Stationery Office.

REFERENCE

1. HUGHES, V. W., WALKER, R. M. Waveforms. Sec. 7.7. (McGraw Hill).

Electronic Machine for Sorting Parcels

AN automatic parcel-sorting machine, the first of its kind in Australia, installed at the Melbourne General Post Office, has as its basis a moving belt which drops parcels through a series of gates into their correct sorting bins. Electronic controls enable a parcel to be sent to the required gate, and this closes again after the parcel falls sideways off the conveyor belt into the receiving bin.

The conveyor belt is 80ft long, and one side of its enclosing frame is composed of 12 gates, representing the classified destination of the postal articles. Thus, there is one gate above the appropriate conveyor bin for City parcels, another for suburban, and others for country and interstate destinations.

There are two operating positions at the launching end of the belt (to which the parcels in bulk are conveyed by another belt, and to a hopper-like table). On each side of the table are two identical control panels, operated by two sorting officers. These panels function by compressed air under the control of the keyboard pre-selector mechanism.

The sorting officers feed the articles into the belt from the pile on the table, but before each presses his button for the gate to which the article is to be directed, he has to get a green signal light on the panel. This is because the preceding parcel has to pass a photocell in the early stages of its journey. Past this point the selector panel automatically receives its green light signal, and the way is clear for another parcel to be placed on the belt.

The arrangement provides for appropriate spacing of the postal articles, and the speed of the general sorting is thus governed by the speed of the moving belt, which is capable of dispatching about 36 a minute.

An additional guide for each of the two operators of the panels is a red light which automatically shows if a button is pressed before a moving parcel has passed the magic eye. Addresses on the parcels are, of course, studied by the operators before pressing the button.

Technically the important units comprise a revolving drum, which is mechanically linked with the belt-driving apparatus, and 12 annular magnetic steel rings mounted on the drum. The latter completes a full revolution during the period in which the sloping belt has travelled from a point near the sorting position to the end of the belt run. Associated with each annular ring, one for each drop panel, is a recording head, magnetic relay and obliterator.

The two control panels; the conveyor belt can be seen passing between the two operators

The Matrix Approach to Filters and Transmission Lines

By M. E. Fisher*

(Part 1)

The use of matrices in the treatment and solution of problems in electronic engineering has become increasingly popular. The matrix approach is flexible and gives a broad and unified outlook on the problems discussed. In recent years it has been applied to various passive network problems[1,2], to the design of phase shifting networks for oscillators[3] and to the theory of quadripoles including thermionic valves as elements[4]. This article is intended to show how the theory of lumped-parameter and continuous transmission lines and filters finds a natural development in the language of matrices. Important concepts in this theory such as the propagation and attenuation constants, the surge or iterative impedances and the nature of the pass and stop bands turn out to be closely related to basic properties of matrices. Only the normal algebra used in a.c. theory is required for matrix methods which thus obviate the need for the calculus and differential equations in the theory of lines.

A simple graphical method for finding the nature of the pass bands of any filter is developed. The method also gives the attenuation and the speed of the waves on a filter, and their variation with frequency. The reason for the large number of circle diagrams used in transmission line theory[6,5] is seen to arise from the properties of a matrix transformation.

THE fundamentals of matrix algebra—addition and multiplication—and the matrix equations for quadripoles have been discussed before in this journal[2-4]. It will be assumed that the reader is familiar with these fundamentals and they will be restated merely to introduce the notation used in this article.

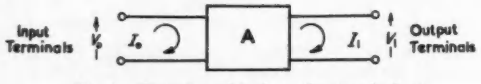


Fig. 1. General quadripole or four-terminal net

Fig. 1 shows a general quadripole and the conventions for the input and output voltages and currents. In terms of these we have the equations:

$$\left.\begin{aligned} V_0 &= a_{11}V_1 + a_{12}I_1 \\ I_0 &= a_{21}V_1 + a_{22}I_1 \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

The coefficients a_{ij} are determined by the structure of the particular quadripole under discussion[3]. If this contains no active elements, such as amplifiers, then the following relation between the coefficients holds as a result of the reciprocity theorem[4].

$$|a_{ij}| = a_{11}a_{22} - a_{12}a_{21} = 1 \quad \ldots\ldots\ldots (2)$$

We will only consider such passive quadripoles.

It is useful to notice that a_{11} and a_{22} are pure numbers while a_{12} has the dimensions of impedance and a_{21} those of admittance.

Equations (1) may be written in matrix notation as:

$$\begin{bmatrix} V_0 \\ I_0 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ I_1 \end{bmatrix} \quad \ldots\ldots\ldots\ldots (3)$$

It is convenient to introduce single symbols to represent the matrices in equation (3). These are distinguished from normal algebraical symbols by the use of heavy type.

$$\mathbf{x}_0 = \begin{bmatrix} V_0 \\ I_0 \end{bmatrix} \quad \mathbf{x}_1 = \begin{bmatrix} V_1 \\ I_1 \end{bmatrix} \quad \mathbf{A} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \ldots (4)$$

The fundamental equation then becomes:

$$\mathbf{x}_0 = \mathbf{A}\mathbf{x}_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

This can be inverted to give the output conditions in terms of the input conditions, i.e.:

$$\mathbf{x}_1 = \mathbf{A}^{-1}\mathbf{x}_0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$\mathbf{A}^{-1}$ is the inverse or reciprocal matrix given in this case by:

$$\mathbf{A}^{-1} = \begin{bmatrix} a_{22} & -a_{12} \\ -a_{21} & a_{11} \end{bmatrix} \quad \ldots\ldots\ldots\ldots\ldots (7)$$

Reverse Quadripole

If a matrix **A** characterizes a given quadripole the matrix corresponding to the reverse quadripole, formed by turning the quadripole around and using the original output terminals as input terminals, can be obtained as follows:

we write $\mathbf{y}_0 = \mathbf{R}\mathbf{y}_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$

by analogy with equation (5). Here **R** is the matrix of the reverse quadripole and $\mathbf{y}_0$ and $\mathbf{y}_1$ are the input and output column matrices for the reverse quadripole. From equation (7) and noting that the sense of the currents must be altered when using the quadripole in reverse we obtain:

$$\mathbf{R} = \begin{bmatrix} a_{22} & a_{12} \\ a_{21} & a_{11} \end{bmatrix} \quad \ldots\ldots\ldots\ldots\ldots (9)$$

A symmetric or reversible quadripole is one which has the same effect whichever pair of terminals is used for the input. In this case the matrices **A** and **R** must be the same which gives as a condition for a quadripole to be reversible that:

$$a_{11} = a_{22} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

(compare equations (4) and (9)).

This condition is illustrated by the matrices of some

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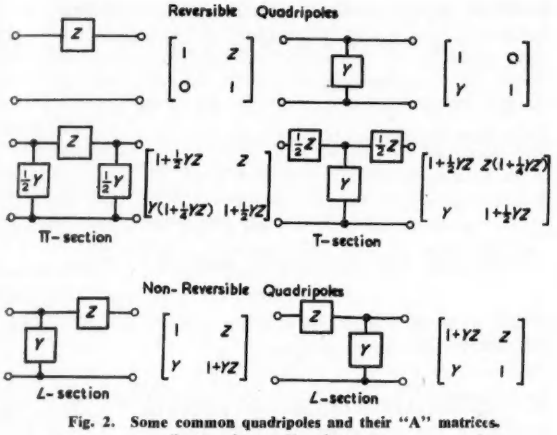


Fig. 2. Some common quadripoles and their "A" matrices.
Z—impedance, Y—admittance

common reversible and non-reversible quadripole networks shown in Fig. 2.

Quadripoles in Cascade

Many quadripole networks encountered in practice are made up of various combinations of simpler quadripoles. In these cases it is very useful to have a direct method of calculating the matrix of the more involved quadripole in terms of those of its constituent quadripoles. Combinations of quadripoles with the terminals in series, parallel or series-parallel are easily dealt with[1]. In particular the matrix

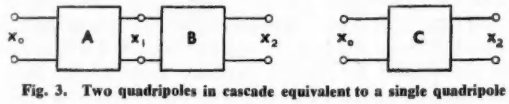


Fig. 3. Two quadripoles in cascade equivalent to a single quadripole

for the overall quadripole formed by connecting two quadripoles in cascade (Fig. 3) can be found by the method of matrix multiplication[3]. In the notation of Fig. 3 we have:

$$\mathbf{x}_0 = \mathbf{A}\mathbf{x}_1 \qquad \mathbf{x}_1 = \mathbf{B}\mathbf{x}_2 \quad \ldots\ldots\ldots\ldots \quad (11)$$

Thus:

$$\mathbf{x}_0 = \mathbf{A}\mathbf{B}\mathbf{x}_2 = \mathbf{C}\mathbf{x}_2 \quad \ldots\ldots\ldots\ldots \quad (12)$$

where the matrix **C**, representing the overall quadripole, is the matrix product **AB** of the two matrices **A** and **B**.

For ladder networks, that is for longer chains of quadripoles, we have further factors in the product. For example, we would have:

$$\mathbf{x}_0 = \mathbf{A}\mathbf{B}\mathbf{C}\mathbf{D}\mathbf{x}_4$$

for a row of four different quadripoles in cascade. Practical application of this principle to *RC* phase shifting networks are illustrated in Ref. 3.

A filter or artificial line is a row of similar quadripoles each with the same matrix. The overall matrix for a chain of n similar quadripoles with matrix **A** is $\mathbf{A}^n$ (repeated application of equation (12) with $\mathbf{A} = \mathbf{B}$).

We have:

$$\mathbf{x}_0 = \begin{bmatrix} V_0 \\ I_0 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^n \begin{bmatrix} V_n \\ I_n \end{bmatrix} = \mathbf{A}^n\mathbf{x}_n \quad \ldots \quad (13)$$

and inverting this:

$$\mathbf{x}_n = \begin{bmatrix} V_n \\ I_n \end{bmatrix} = (\mathbf{A}^n)^{-1} \begin{bmatrix} V_0 \\ I_0 \end{bmatrix} = \mathbf{A}^{-n}\mathbf{x}_0 \quad \ldots\ldots \quad (14)$$

These two matrix equations relating the input and output voltages and currents are the basic equations of the theory of lines and filters. Later they will appear in more familiar form. ($\mathbf{A}^{-n}$ is the matrix inverse of $\mathbf{A}^n$).

Vector Interpretation

Equation (13) relates the two column matrices $\mathbf{x}_0$ and $\mathbf{x}_n$. Each of these depends on two numbers, one representing a voltage and the other a current. These two numbers can be regarded as the two components of a vector in a plane. Thus $\mathbf{x}_0$ can be interpreted as a vector with components (I_0, V_0) and $\mathbf{x}_n$ as a vector with components (I_n, V_n). These vectors can be represented on a diagram (Fig. 4) using two perpendicular axes to represent current and voltage. As, however, we are in general concerned with alternating currents the components of the vector $\mathbf{x}$ (I, V) will be complex numbers which cannot be represented directly as distances along a single axis. In spite of this it is useful to regard V and I as single magnitudes and interpret them, symbolically if not directly, by the distances along two axes in a plane.

With this interpretation of $\mathbf{x}_0$ and $\mathbf{x}_n$ the matrix $\mathbf{A}^n$ appears as an "operator" which when applied to the vector $\mathbf{x}_n$ transforms it, by rotation and extension into the new vector $\mathbf{x}_0$. $\mathbf{A}^{-n}$ is the inverse operator which generates $\mathbf{x}_n$

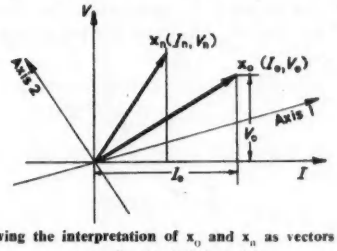


Fig. 4. Showing the interpretation of $\mathbf{x}_0$ and $\mathbf{x}_n$ as vectors and the two axes of a typical A matrix

when applied to $\mathbf{x}_0$, i.e., cancels the effect of $\mathbf{A}^n$. The matrix **A** alone is an operator which when it operates n times in succession on $\mathbf{x}_n$ transforms it successively into $\mathbf{x}_{n-1}, \mathbf{x}_{n-2}$ . . . and finally into $\mathbf{x}_0$. The interpretation of a square matrix as a vector operator is a useful aid in considering the effect of a line or filter on a given applied voltage and current.

Propagation Along an Artificial Line

Consider an infinite line of similar quadripoles each with matrix **A** connected in cascade. A single wave propagating along this line is characterized by the fact that the voltage and current suffer the same change in phase and the same attenuation (or amplification) as the wave passes across any quadripole. In other words, voltage and current at the n^{th} pair of terminals are equal to the voltage and current at the $(n+1)^{th}$ pair multiplied by a constant factor (possibly complex). The value of this factor will determine the nature and the speed of the propagation. We can write:

$$\mathbf{x}_n = \xi\mathbf{x}_{n+1} \quad \ldots\ldots\ldots\ldots\ldots \quad (15)$$

where ξ is a constant. Furthermore, since the matrix of the quadripoles is **A**

$$\mathbf{x}_n = \mathbf{A}\mathbf{x}_{n+1} \quad \ldots\ldots\ldots\ldots\ldots \quad (16)$$

Thus for a particular type of quadripole the constant ξ must be determined from the equation.

$$\mathbf{A}\mathbf{x} = \xi\mathbf{x} \quad \ldots\ldots\ldots\ldots\ldots \quad (17)$$

The subscript $(n+1)$ may be omitted since it is irrelevant here. This equation may be interpreted directly in terms

of our vector representation of **x**. It implies that **x** must be a vector such that the effect of operating on it with **A** is to leave it unaltered except for a change in magnitude by a factor ξ. The direction of **x** is not affected. Any vector, say **w**, fulfilling this condition is called an *eigen-vector* of the operator matrix **A** (from the German *eigen* meaning self, since, except for the magnitude, **w** is transformed into itself). The value of ξ corresponding to a particular eigen-vector **w** is called the *eigen-value* of the matrix for the vector **w**. The terms *characteristic* or *latent roots* of the matrix or *proper value* are also used for ξ. The directions determined by the eigen vectors of a particular matrix are sometimes called the *axes* of the matrix[7]. (see Fig. 4.)

We can determine the eigen-values of the matrix **A** as follows. Equation (17) is equivalent to:

$$\begin{aligned} (a_{11} - \xi)V + \quad a_{12} I &= 0 \\ a_{21} V + (a_{22} - \xi) I &= 0 \end{aligned} \quad \ldots\ldots\ldots (18)$$

These two equations can only be consistent if:

$$\begin{vmatrix} a_{11} - \xi & a_{12} \\ a_{21} & a_{22} - \xi \end{vmatrix} = 0 \quad \ldots\ldots\ldots (19)$$

This equation is the *characteristic equation* of the matrix and is well known in many applications of matrix theory. For example it is used to determine the frequencies of vibration of an aircraft wing and the behaviour of an electron in a crystal.

Using the fact that $|a_{ij}| = 1$ it can be written:

$$\xi^2 - (a_{11} + a_{22})\xi + 1 = 0 \quad \ldots\ldots\ldots (20)$$

Solving this quadratic equation gives two values for ξ, the eigen-values

$$\xi_1 = \tfrac{1}{2}a_0 + \sqrt{[(\tfrac{1}{2}a_0)^2 - 1]}$$

and $\ldots\ldots\ldots (21)$

$$\xi_2 = \tfrac{1}{2}a_0 - \sqrt{[(\tfrac{1}{2}a_0)^2 - 1]}$$

where:

$$a_0 = a_{11} + a_{22} \quad \ldots\ldots\ldots (22)$$

is the sum of the diagonal elements of the matrix and is called the *trace* or *spur* of the matrix **A**. This plays an important part in what follows.

From equation (21):

$$\xi_1 \xi_2 = 1 \quad \ldots\ldots\ldots (23)$$

If we write: $\xi_1 = e^{\gamma}$

then: $\xi_2 = e^{-\gamma}$ $\ldots\ldots\ldots (24)$

where γ is a complex number

$$\gamma = \alpha + j\beta \quad \ldots\ldots\ldots (25)$$

(α and β real) called the *propagation constant*.

The significance of the propagation constant is well known and can be seen if we suppose that $\mathbf{w}_1$ and $\mathbf{w}_2$ are two eigen-vectors of **A** corresponding to the eigen-values ξ_1 and ξ_2. $\mathbf{w}_1$ and $\mathbf{w}_2$ represent the voltages and currents at some point of the chain. Then by equation (19):

$$\mathbf{A}\mathbf{w}_1 = \xi_1 \mathbf{w}_1 \quad \mathbf{A}\mathbf{w}_2 = \xi_2 \mathbf{w}_2 \quad \ldots\ldots\ldots (26)$$

If the voltages and currents are varying harmonically in time with frequency $\nu = \omega/2\pi$ we may write:

$$\mathbf{w}_1 = \mathbf{w}^{\mathrm{I}} e^{j\omega t} = \begin{bmatrix} V^{\mathrm{I}} e^{j\omega t} \\ I^{\mathrm{I}} e^{j\omega t} \end{bmatrix} \quad \ldots\ldots\ldots (27)$$

and:

$$\mathbf{w}_2 = \mathbf{w}^{\mathrm{II}} e^{j\omega t} = \begin{bmatrix} V^{\mathrm{II}} e^{j\omega t} \\ I^{\mathrm{II}} e^{j\omega t} \end{bmatrix}$$

Using $\mathbf{w}_1$ and $\mathbf{w}_2$ as $\mathbf{x}_0$ in equation (14) we obtain:

$$\mathbf{x}_n = \mathbf{A}^{-n}\mathbf{x}_0 = \mathbf{A}^{-n}\mathbf{w}_1 = \xi_1^{-n}\mathbf{w}^{\mathrm{I}} e^{j\omega t} \quad \ldots\ldots (28)$$

or:

$$\mathbf{x}_n = \mathbf{A}^{-n}\mathbf{x}_0 = \mathbf{A}^{-n}\mathbf{w}_2 = \xi_2^{-n}\mathbf{w}^{\mathrm{II}} e^{j\omega t}$$

Then from equations (24) and (25):

$$\mathbf{x}_n = \mathbf{w}^{\mathrm{I}} e^{j\omega t - \gamma n} = \mathbf{w}^{\mathrm{I}} e^{-\alpha n} e^{j(\omega t - \beta n)} \quad \ldots\ldots (29)$$

or:

$$\mathbf{x}_n = \mathbf{w}^{\mathrm{II}} e^{j\omega t + \gamma n} = \mathbf{w}^{\mathrm{II}} e^{\alpha n} e^{j(\omega t + \beta n)} \quad \ldots\ldots (30)$$

Equations (29) and (30) represent waves of frequency:

$$\nu = \omega/2\pi = 1/\tau \quad \ldots\ldots\ldots (31)$$

(where τ is the period and ω the pulsatance or angular frequency) and wave number:

$$k = \beta/2\pi = 1/\lambda \quad \ldots\ldots\ldots (32)$$

(λ is the wavelength of the wave measured in units of the spacing of the quadripoles or filter sections). β may also be interpreted as the phase change per quadripole. The wave represented by equation (29) travels to the right with decaying amplitude controlled by the decrement or attenuation α. The power attenuation of the wave due to one quadripole or filter section is given by:

$$A = 8{\cdot}68\alpha \text{ decibels} \quad \ldots\ldots\ldots (33)$$

Equation (30) represents a similar wave travelling to the left. If $\alpha = 0$ both these waves propagate freely without attenuation. The speed of the waves is given by:

$$c = \lambda/\tau = \omega/\beta \quad \ldots\ldots\ldots (34)$$

in units of quadripole spacing per second.

Thus the two eigen-values ξ_1 and ξ_2 of the matrix **A** correspond to two independent waves of voltage and current travelling in opposite directions with speed and attenuation determined by the propagation constant γ. This in turn is fully determined by the coefficients of the **A** matrix.

Note that the reverse quadripole with matrix **R** given by equation (10), has the same eigen-values and eigen-vectors as the direct quadripole, but in reverse order.

Attenuation and Pass-Bands

If the waves are to be transmitted along the line of quadripoles without attenuation we must have $\alpha = 0$; in other words γ must be purely imaginary, so that:

$$\xi = e^{\pm\gamma} = e^{\pm j\beta} \quad \ldots\ldots\ldots (35)$$

For a given quadripole this will usually be possible only for certain frequencies. Our aim is to determine what frequencies can be freely transmitted. Equation (20) gives ξ in terms of the trace $a_0 = a_{11} + a_{22}$, but it can be rewritten to give a_0 in terms of ξ.

$$a_0 = \xi + 1/\xi \quad \ldots\ldots\ldots (36)$$

If there is to be no attenuation, ξ is restricted by equation (35) so a_0 is also restricted,

$$a_0 = e^{\mp j\beta} + e^{\pm j\beta} = (\cos\beta \pm j\sin\beta) + (\cos\beta \mp j\sin\beta)$$

i.e.:

$$a_0 = 2\cos\beta = 2\cos 2\pi k \quad \ldots\ldots\ldots (37)$$

using equation (32).

Now $\cos\beta$ can take any values between $+1$ and -1 inclusive and is always real since β is real by definition. The condition for unattenuated propagation is thus:

(i) The trace of the matrix, a_0, must be real, $a_0 = a_0^*$; and (ii):

$$-2 \leqslant a_0 \leqslant 2 \quad \ldots\ldots\ldots (38)$$

a_0 depends on the coefficients of the **A** matrix which in turn are determined by the impedances and admittances of the quadripole. These impedances and admittances vary with the frequency, i.e., with ω, so that equation (37) determines those frequencies for which the line acts as a pass-band filter.

Frequencies for which a_0 does not satisfy equation (38) will be attenuated. In a filter with negligible resistance a_0 is always real since it depends only on products or ratios of pure reactances. Then if a_0 is outside the range -2 to $+2$ the eigen-value ξ will be purely real by equation (21). In this case β is zero and $\gamma = \alpha$ so that equation (30) becomes:

$$|a_0| = \xi + 1/\xi = e^{\pm\alpha} + e^{\mp\alpha}$$

i.e.:

$$|a_0| = 2\cosh\alpha \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (39)$$

($|a_0|$ is the modulus or absolute value of a_0 irrespective of sign.)

This shows how the attenuation depends on the value of the trace of the matrix outside a pass band. If a_0 is large equation (39) can be approximately written $\alpha = \ln|a_0|$ which gives the power attenuation per section as:

$$A = 20{\cdot}0 \log_{10}|a_0| \text{ decibels} \quad \ldots\ldots\ldots \quad (40)$$

Application to Practical Filters

We will illustrate the use of the criterion equation (38)

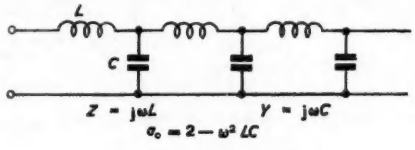


Fig. 5(a). Low-pass filter

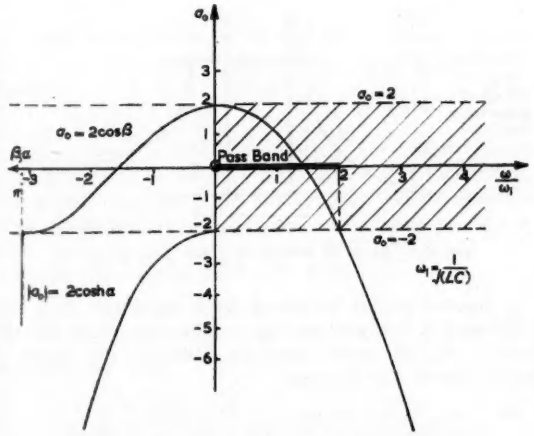
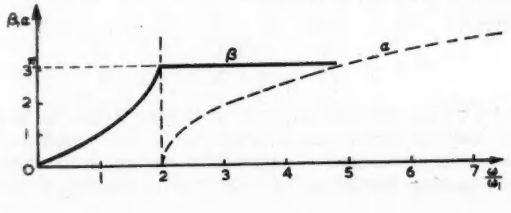


Fig. 5(b). Graph of the trace a_0 against frequency ω

Fig. 5(c). Graph of attenuation α, and phase charge β, against ω



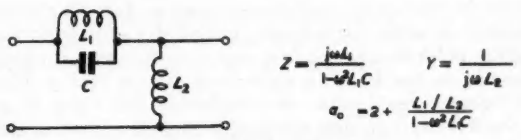


Fig. 6(a). High-pass filter section

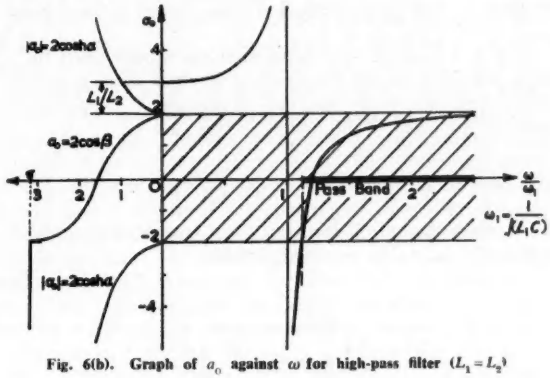


Fig. 6(b). Graph of a_0 against ω for high-pass filter ($L_1 = L_2$)

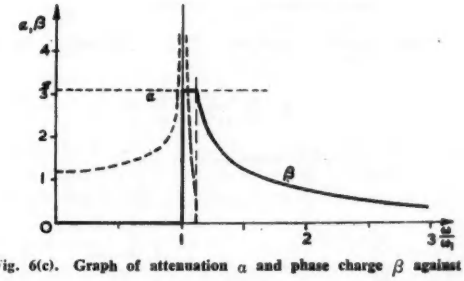


Fig. 6(c). Graph of attenuation α and phase charge β against ω

by discussing various filters formed of *L*-type sections shown in Fig. 2. The argument would equally well apply to the reversible π or *T* networks. For all these types of quadripole the trace of the matrix is:

$$a_0 = 2 + YZ \quad \ldots\ldots\ldots\ldots\ldots \quad (41)$$

where Z is the series impedance and Y the parallel admittance of one section.

Consider the simple low-pass filter of Fig. 5(a). Here the trace is:

$$a_0 = 2 - \omega^2 LC \quad \ldots\ldots\ldots\ldots\ldots \quad (42)$$

which will always be real, hence fulfilling the first condition of equation (38). In Fig. 5(b) a graph of a_0 against ω the pulsatance or angular frequency is plotted for positive ω. In this case the graph is merely an inverted parabola. Now by equation (38) when a_0 is between -2 and $+2$ the attenuation is zero. To find what band of frequencies the filter will pass we examine the curve of a_0 against ω. Where this curve falls between the two horizontal lines $a_0 = 2$ and $a_0 = -2$ shown in Fig. 5(b) the filter will pass the waves. This shows that this filter will pass low frequencies from $\omega = 0$ to $\omega = 2/\sqrt{LC}$, while frequencies greater than this will be attenuated.

Fig. 5(c) shows graphs of the attenuation α, and β the phase change per section, against ω. These can be obtained directly from the graph of a_0 by use of the two graphs:

$$a_0 = 2\cos\beta \text{ and } |a_0| = 2\cosh\alpha$$

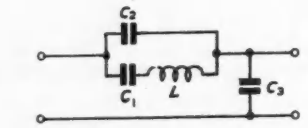
(equations (37) and (39)).

which are plotted on the left-hand side of Fig. 5(b) using the same a_0 axis. For example, to find the attenuation for a given pulsatance ω the first step is to find the a_0 corresponding to this from the right-hand portion of Fig. 5(b). The second step consists in transferring this value of a_0 to the left-hand portion where a_0 is plotted against α, and finding the value of α corresponding to this value of a_0. This value of α is then the attenuation appropriate to the original ω. The same method is used to find β for a given ω.

In Fig. 6 a similar graphical analysis is performed for a high-pass filter having a frequency at which there is infinite attenuation just below the cut-off frequency. The expression for the trace of the matrix in this case is:

$$a_0 = 2 + \frac{L_1/L_2}{1 - \omega^2 L_1 C}$$

from which the cut-off frequency and frequency for infinite attenuation can be obtained directly.



$$Z = \frac{1 - \omega^2 LC_1}{j\omega(C_2 + C_1 - \omega^2 LC_1C_2)} \qquad Y = j\omega C_3$$

$$a_0 = 2 + \frac{C_3}{C_2} \cdot \frac{1 - \omega^2 LC_1}{1 + \frac{C_1}{C_2} - \omega^2 LC_1}$$

Fig. 7(a). Band-pass filter section

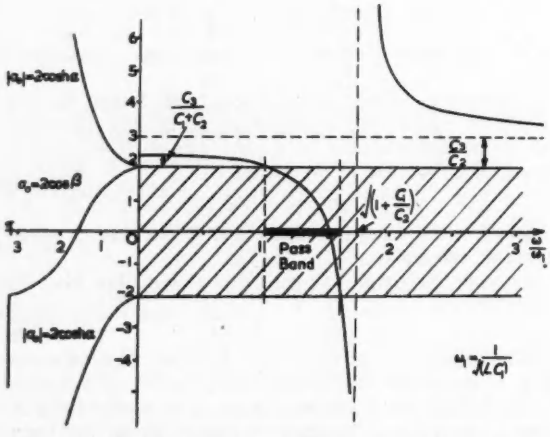
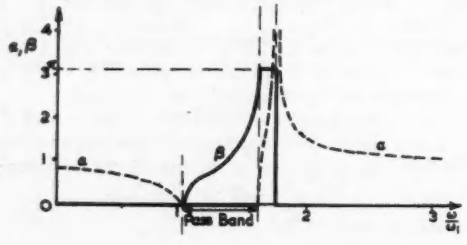
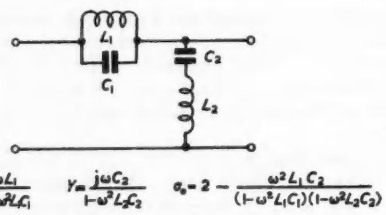


Fig. 7(b). Graph of a_0 against ω, for band-pass filter ($C_1 = 2C_2 = 2C_3$)

Fig. 7(c). Graph of attenuation α, and phase charge β against ω





$$Z = \frac{j\omega L_1}{1 - \omega^2 L_1 C_1} \qquad Y = \frac{j\omega C_2}{1 - \omega^2 L_2 C_2} \qquad a_0 = 2 - \frac{\omega^2 L_1 C_2}{(1 - \omega^2 L_1 C_1)(1 - \omega^2 L_2 C_2)}$$

Fig. 8(a). Band-stop filter section

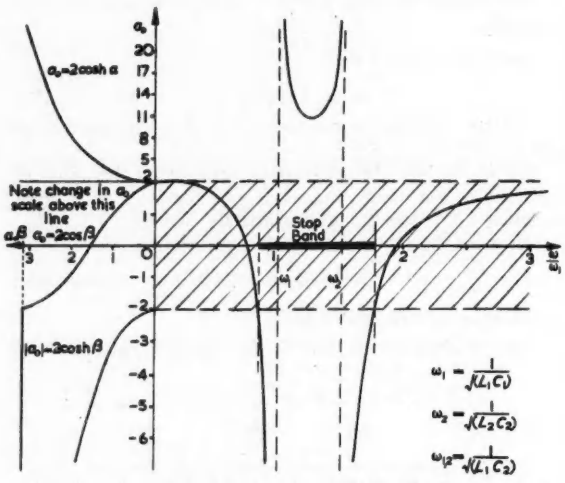


Fig. 8(b). Graph of a_0 against ω for band-stop filter. ($\omega_1 = \omega_{12} = \frac{1}{2}\omega_2$)

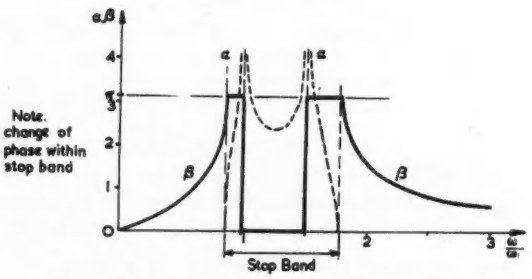


Fig. 8(c). Graph of attenuation α and phase charge β

A band-pass filter utilizing three capacitors and one inductance is analysed in Fig. 7. The expression for the trace is slightly more involved, although the graph is readily drawn. In this case:

$$a_0 = 2 + C_3/C_1 \cdot \frac{1 - \omega^2 LC_1}{1 + C_2/C_1 - \omega^2 LC_2}$$

Finally Fig. 8 shows the attenuation and phase change obtained from a band-stop filter with two frequencies of infinite attenuation in the band.

Here:

$$a_0 = 2 - \frac{\omega^2 L_1 C_2}{(1 - \omega^2 L_1 C_1)(1 - \omega^2 L_2 C_2)}$$

Using this graphical analysis it is easy to devise filters with any particular pass characteristics or to predict the behaviour of a more involved filter section with one or more passing bands.

Impedances Corresponding to the Axes of the Matrix

The matrix equation (17) $\mathbf{Ax} = \xi\mathbf{x}$ enabled us to determine ξ_1 and ξ_2, the two eigen-values of the matrix. On the basis of the vector interpretation of matrices it was shown how only certain of the vectors $\mathbf{x}$ could possibly satisfy this equation. These are the eigen-vectors of $\mathbf{A}$, $\mathbf{w}_1$ and $\mathbf{w}_2$, corresponding to eigen-values ξ_1 and ξ_2 respectively. One can write:

$$\mathbf{w}_1 = \begin{bmatrix} V' \\ I' \end{bmatrix} \qquad \mathbf{w}_2 = \begin{bmatrix} V'' \\ I'' \end{bmatrix} \quad \ldots\ldots\ldots (43)$$

These two eigen-vectors determine the *axes of the matrix* (see Fig. 9). The slopes of the two axes are:

$$m_1 = V'/I' \text{ and } m_2 = V''/I'' \quad \ldots\ldots\ldots (44)$$

It should be noted that if $\mathbf{w}_1$ is an eigen-vector of a matrix $\mathbf{A}$ for eigen-value ξ_1 then any constant multiple of $\mathbf{w}_1$ such as $c\mathbf{w}_1$ is also an eigen-vector for the same eigen-value. So that whatever particular eigen-vector is chosen the slope of the axis is completely determined by equation (44). All possible eigen-vectors lie along one or other of the two axes.

Now the slopes m_1 and m_2 have the dimensions of

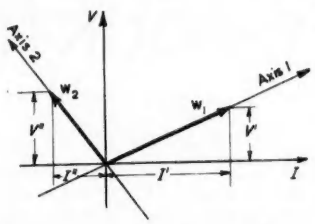


Fig. 9. Showing two eigen-vectors of a matrix

impedance (voltage divided by current). We use them to define two *characteristic impedances* for the particular quadripole.

$$z_1 = m_1 = V'/I' \qquad z_2 = m_2 = V''/I'' \quad \ldots\ldots (45)$$

It will be seen that these impedances are closely related to the two *surge* or *iterative impedances* of a quadripole.

To evaluate z_1 and z_2 in terms of the matrix elements of the quadripole we write out the matrix equation $\mathbf{Ax}=\xi\mathbf{x}$ in full using the two known values of ξ_1 and ξ_2.

For the first eigen-value this gives

$$\begin{aligned} a_{11}V' + a_{12}I' &= \xi_1 V' \\ a_{21}V' + a_{22}I' &= \xi_1 I' \end{aligned} \quad \ldots\ldots\ldots (46)$$

From this we have

$$z_1 = V'/I' = \frac{a_{12}}{\xi_1 - a_{11}} \text{ or } z_1 = \frac{\xi_1 - a_{22}}{a_{21}} \quad \ldots. (47)$$

and a similar expression for z_2 involving ξ_2 in place of ξ_1. Substituting for ξ in terms of the coefficients (equation 21) one obtains

$$z_1 = \frac{(a_{11} - a_{22})}{2a_{21}} + \frac{\sqrt{\{(\tfrac{1}{2}a_0)^2 - 1\}}}{a_{21}}$$

$$z_2 = \frac{(a_{11} - a_{22})}{2a_{21}} - \frac{\sqrt{\{(\tfrac{1}{2}a_0)^2 - 1\}}}{a_{21}} \quad \ldots\ldots (48)$$

where $a_0 = a_{11} + a_{22}$, is the trace of the matrix as before.

For a symmetric or reversible quadripole such as the usual π or T sections the matrix elements a_{11} and a_{22} are equal (equation 10)). In this case the expression for the characteristic impedances greatly simplifies.

$$z_1 = \sqrt{(a_{12}/a_{21})} \qquad z_2 = \sqrt{(a_{12}/a_{21})} \quad \ldots\ldots (49)$$

so that $z_1 = -z_2$ for a reversible quadripole.

Surge or Iterative Impedances

We will now examine the relation between these characteristic impedances of a quadripole determined from the slopes of the axes of the matrix, and the two iterative impedances of a quadripole met with in normal filter theory. The forwards iterative impedance of a quadripole is defined as the impedance looking into an infinite line of quadripoles connected in cascade. The reverse iterative impedance is similarly defined to be the impedance looking into an infinite chain of reversed quadripoles. We denote these impedances by ζ_1 and ζ_2 respectively*. The iterative impedances can be evaluated in terms of the matrix coefficients by considering the effect of removing one quadripole from the beginning of the line. Obviously since the line is infinite the situation is really unaltered and the impedance looking into the chain is still ζ_1 (Fig 10).

As always if the matrix of the quadripole is $\mathbf{A}$ we have that

$$\mathbf{x}_0 = \mathbf{Ax}_1 \quad \ldots\ldots\ldots\ldots (50)$$

where in this case

$$\mathbf{x}_0 = \begin{bmatrix} V_0 \\ I_0 \end{bmatrix} = \begin{bmatrix} \zeta_1 I_0 \\ I_0 \end{bmatrix} \qquad \mathbf{x}_1 = \begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} \zeta_1 I_1 \\ I_1 \end{bmatrix} \quad \ldots. (51)$$

The second relation in each of these equations follows since the impedance is the same whether measured at the 0^{th} pair of terminals or the 1^{st} pair, i.e., $V_0 = \zeta_1 I_0$ and

Fig. 10. Illustrating the fact that the input impedance of an infinite chain is unaltered by removal of one quadripole

$V_1 = \zeta_1 I_1$. Substituting these values for $\mathbf{x}_0$ and $\mathbf{x}_1$ and writing out the matrix equation in full we obtain

$$\begin{aligned} \zeta_1 I_0 &= (a_{11}\zeta_1 + a_{12})I_1 \\ I_0 &= (a_{21} + a_{22}\zeta_1)I_1 \end{aligned} \quad \ldots\ldots\ldots\ldots (52)$$

Eliminating the currents from these equations gives

$$a_{21}\zeta_1^2 - (a_{11} - a_{22})\zeta_1 - a_{12} = 0 \quad \ldots\ldots (53)$$

Solving this gives the forwards iterative impedance ζ_1 in terms of the matrix coefficients:

$$\zeta_1 = \frac{(a_{11} - a_{22})}{2a_{21}} + \frac{\sqrt{\{(\tfrac{1}{2}a_0)^2 - 1\}}}{a_{21}} \quad \ldots\ldots\ldots (54)$$

The positive sign for the root must be taken since ζ_1 must have a positive real part; resistance is always positive. The reverse iterative impedance can be determined by an exactly similar argument using the matrix of the reverse quadripole (equation 9) which merely has a_{11} and a_{22} interchanged. Thus:

$$\zeta_2 = -\left[\frac{(a_{11} - a_{22})}{2a_{21}} - \frac{\sqrt{\{(\tfrac{1}{2}a_0)^2 - 1\}}}{a_{21}}\right] \quad \ldots\ldots (55)$$

** The Greek letter ζ, zeta, is used here to avoid writing further subscripts on the over-worked letter Z.*

If these expressions for the iterative impedances are compared with those for the characteristic impedances (equation 48) it will be seen that:

$$\zeta_1 = z_1 \text{ and } \zeta_2 = -z_2 \quad \ldots\ldots\ldots\ldots \quad (56)$$

In other words, except for a change of sign the iterative impedances are exactly the characteristic impedances determined by the slopes of the axes or eigen-vectors!

On reflexion this is not so surprising since, as we have shown, the eigen-vectors of the two eigen-values correspond to two independent waves propagating in opposite directions with a relation between voltage and current determined by the slope of the eigen-vectors. As is well known, such waves are not reflected if the line is matched, that is terminated with the appropriate iterative impedance. With such an arrangement the correct relationship between voltage and current is maintained at the end of the line for propagation in one direction only.

For a reversible quadripole $a_{11} = a_{22}$ and the two iterative impedances become identical.

$$\zeta_1 = \zeta_2 = \zeta = \sqrt{(a_{12}/a_{21})} \quad \ldots\ldots\ldots\ldots \quad (57)$$

as would be expected on physical grounds.

(To be continued)

REFERENCES

1. SIMMONDS, J. C. Matrix Algebra and the Solution of Electrical Network Problems. *Electronic Engng. 16*, 160 (1943); *16*, 272 (1943).
2. (*a*) BIGGAR, H. P. Application of Matrices to Four-terminal Network Problems. *Electronic Engng. 23*, 307 (1951).
   (*b*) BIGGAR, H. P. Transfer Matrix of a Four-terminal Passive Network in Terms of its Image Parameters. *Electronic Engng. 25*, 152 (1953).
3. (*a*) HINTON, W. R. Design of RC Oscillator Phase Shifting Networks. *Electronic Engng. 22*, 13 (1950).
   (*b*) HINTON, W. R. Measurement of "A" Matrix Elements of a Passive Network. *Electronic Engng. 25*, 151 (1953).
4. DEARDS, S. R. Matrix Theory Applied to Thermionic Valve Circuits. *Electronic Engng. 24*, 264 (1951).
5. GUPTA, Q. C., DUERDEN, F. Geometrical Solution of Some Transmission Line Problems. *Electronic Engng. 22*, 525 (1950).
6. JACKSON, WILLIS. High Frequency Transmission Lines. Ch. VI. (Methuen's Monograph Series).
7. BRILLOUIN, L. Wave Propagation in Periodic Structure. Ch. IX and X. (McGraw Hill Book Company).
8. PIPES, L. A. Matrix Theory of Four Terminal Networks. *Phil. Mag. 30*, 370 (1940).

A REVERSIBLE BINARY COUNTER

By R. W. Fenemore*

A binary counter is described, which will both "add" and "subtract" from the total registered. Control and input signals are required. A control switching unit is described, and reference is made to a practical version of the complete reversible binary counter. One example is the digital analogue convertor, and the other use of a counter in conjunction with an interpolator.

COUNTERS are used extensively in industrial process and control systems, as well as in general scientific investigations. Usually these counters are purely summation devices in that they record the sum of the total number of input signals received.

For some applications it may be necessary to both add and subtract from the total registered by the counter. In this case, the counter must be supplied with both control and input signals. The control signals indicate to the counter whether particular input pulses should be added or subtracted from the total registered by the counter. Such counters are generally termed "reversible," and this article will describe a reversible binary counter.

For an example of the use of a reversible counter, it may be required to indicate the total number of items already in store, to and from which items are being added or removed. Another example is the application of corrections to counts already made and registered in the counter. These corrections may be either negative or positive. A final illustration is the use of a reversible counter to indicate the actual position of a member when it has been subjected to a series of forward and reverse movements. The counter is used to keep a running total of instructions to the member and so indicate its true position. This system is employed as part of the control of a milling machine operating from input information, which is digital in form.

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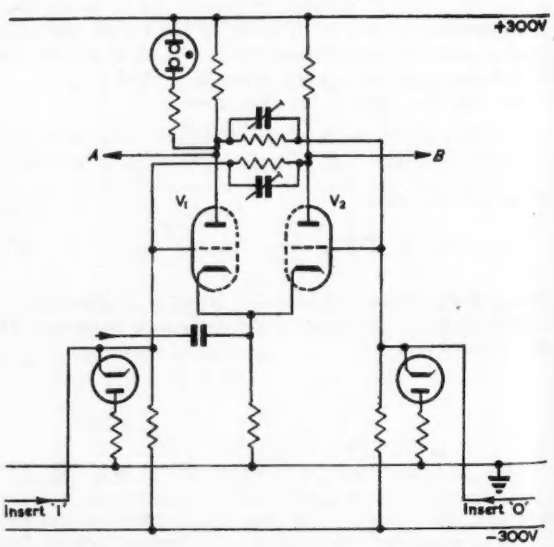
Bistable Multivibrators as Counters

Multivibrators have been used as binary counters for a long time. An example of such a counter stage is shown

Fig. 1. Basic counter stage



in Fig. 1. Let this counter stage represent "0" when valve V_1 is conducting and "1" when it is cut off, i.e. when valve V_2 is conducting.

For the process of addition, a carry-forward signal is required to operate the next stage when the counter changes from "1" to "0." This signal may be obtained in several ways, two of which are:

(a) from the anode of V_1 when it changes from being cut off to conducting,

(b) from the anode of V_2 when it changes from being conducting to cut off.

A sharper edge pulse is obtained at the anode of a valve when it is made to conduct than when it is cut off. This is because drawing current through the valve charges the stray capacitances at the anode of the valve more quickly than the charge leaks away when the valve is cut off. Hence the most suitable signal for triggering the

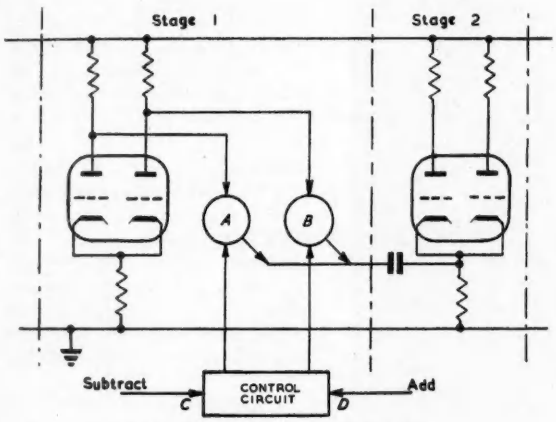


Fig. 2. Basic add-subtract counter stage

succeeding stage of the counter is obtained from condition (a) above—point A Fig. 1. For subtraction, a similar argument leads to the selection of a triggering pulse for the succeeding stage from the anode of V_2 when it is made to conduct—point S Fig. 4.

Modification for Add-Subtract Facilities

For a counter that will both add and subtract, the foregoing leads to the circuit arrangement of Fig. 2. In this arrangement, gates A and B are placed in the triggering circuits between consecutive stages of the counter. Trigger pulses for the second stage of the counter are selected from either one of the anodes of the valves in the first stage by the gates A and B. The gates are operated differentially and only one is open at any time. The control circuit which determines the gate to be opened operates on the receipt of the add or subtract control signals associated with the counting pulses which are fed to the input of the counter.

Practical Circuit Arrangement

A practical circuit arrangement for a reversible binary counter is shown in Fig. 3. Two counter stages only are shown, one represented by valves V_1 and V_2, the other by valves V_5 and V_6. The interstage gating circuits are provided by diodes V_3 and V_4. Differential potentials applied to lines X and Y determine whether the counter shall add or subtract. In this particular arrangement these biasing potentials are about either -150V and 0V.

The biasing potentials for controlling the interstage gating circuits may be obtained from an electronic switch, e.g. a circuit similar to that employed in the counter stage itself. The biasing potentials are taken from the two

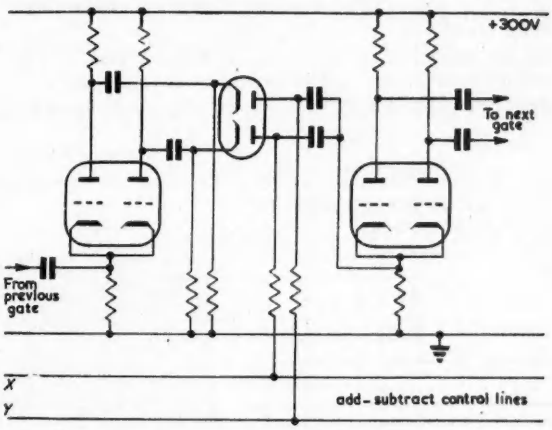


Fig. 3. Circuit of single stage add-subtract counter

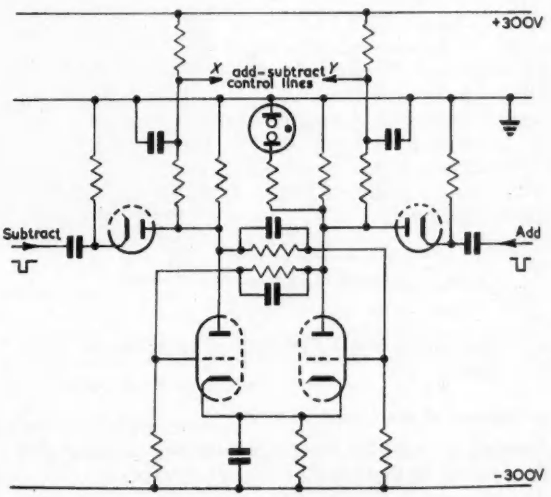


Fig. 4. Add-subtract switch

anodes of the valves forming the bistable pair. An example of such a switch is shown in Fig. 4.

The switch is tripped into one of its two stable states by negative control pulses on leads A and B. Biasing potentials are supplied to the main counter stages from the anode of the valves V_3 and V_4 at points X and Y. When valve V_3 is conducting, the potential of point Y is about -150V and that of point X about earth. With the switch in this position, the counter will be in the subtract condition. When separate control pulses are not available, they must be generated from the counting pulses. It is necessary to introduce a small delay in the signal path to

the counter input. This permits the electronic switch to operate and set the counter in the appropriate state before counting pulses reach the input of the counter.

The design of the add-subtract switch requires to be related to that of the counter stage. If this is not done, the switching of the bias potentials at the interstage gating circuits may cause spurious trigger pulses to appear at succeeding counter stages. To overcome this, the counter stages are made to operate only on trigger pulses which have a rise time smaller than the switching time of the biasing potentials.

In the particular arrangement of Figs. 3 and 4, the switching time of the control circuits is about 10μsec and trigger pulses for operation of the counter stages need to have a rise time of about 0·01μsec and amplitude of about 20V negative.

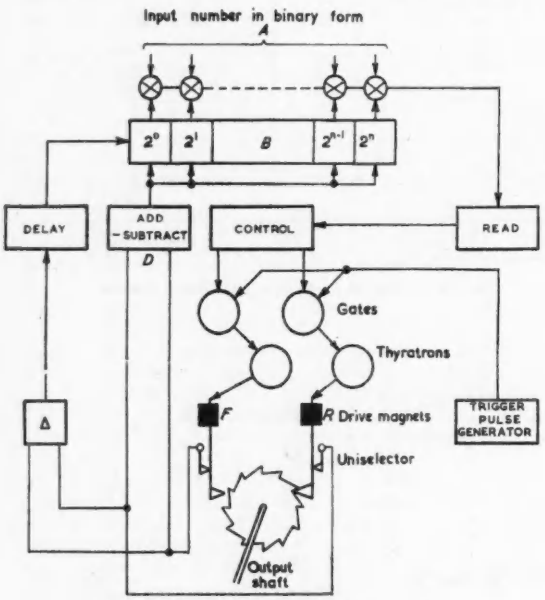


Fig. 5. Example of digital-analogue convertor

Applications of the Counter

Uses of a reversible binary counter are manifold, but only two will be described by way of example.

The first illustration is the use of the counter as a component in a digital analogue convertor. The general arrangement of the system is shown in Fig. 5. It is required to convert to a shaft rotation information which is presented to the convertor in the form of a binary number. The output shaft is driven through suitable reduction gearing by a bothway uniselector. The position of this shaft is registered as a binary number in the counter B. Auxiliary contacts on the uniselector generate pulses each time the shaft is stepped in either the forward or reverse direction. Pulses representing forward motion are added and those representing reverse motion are subtracted from the total in the counter. The required position of the output shaft in binary form is compared with the position of the output shaft as registered by the binary counter. The difference is used to generate an error signal which controls the motion of the uniselector. The driving magnets of the uniselector may be energized through thyratrons which are controlled by two gate circuits; the gates pass triggering pulses to the appropriate driving circuit thyratron when there is an error signal.

The system is a closed loop system and hence conditions for stability of such systems must be satisfied. However, it is a sufficient, though not a necessary, condition for stability if the repetition rate of the trigger pulses is such that, after operation of the uniselector, the new error signal is fed to the control gates before the next trigger pulse appears. This limits the maximum rate of change of input information which the system will follow without large transient errors.

The second example concerns the use of the counter as part of a digital data interpolator. A block schematic arrangement is shown in Fig. 6 (a), and the mode of operation will be clear by reference to Fig. 6 (b). The value of Y_N is inserted in parallel into the counter at the beginning of an interpolation interval, e.g. at point X_N for the interval X_N to $X_N + 1$. Data for the calculation of the value ΔY is inserted in the interpolator at the same time. The output of the interpolator consists of a series of pulses. The repetition rate of the pulse is proportional to the slope of the curve. Pulses are fed to the reversible counter, and the total indicated by the counter is the value $Y_N + \Delta Y$, i.e. the value of Y corresponding to the value of X. At the end of the interpolation interval, the new value Y, i.e. $Y_N + 1$, is inserted into the counter and interpolation proceeds as before.

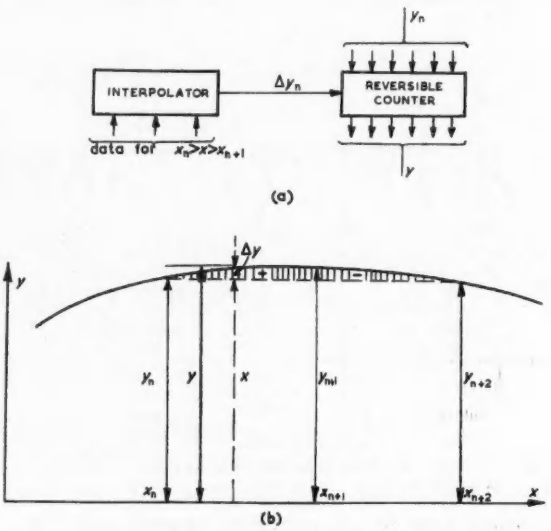


Fig. 6. Reversible counter used in interpolator

Acknowledgments

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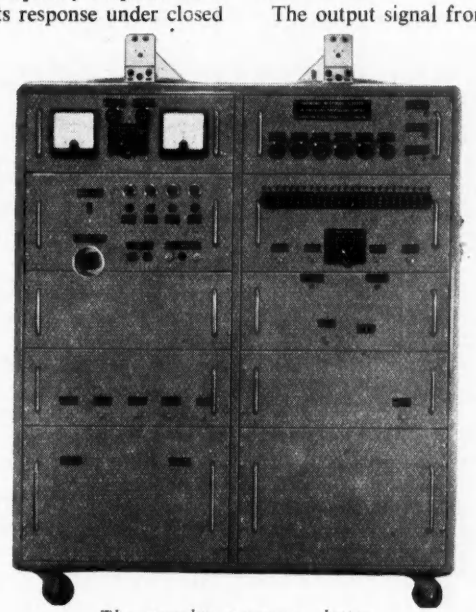
A HARMONIC RESPONSE PLOTTER

By Z. Czajkowski*, B.Sc.

An instrument is described which simultaneously plots a harmonic response diagram of a servo system and its first derived plot. The range of the instrument is from 0·2c/s to 104c/s in 100 steps which are marked on both diagrams. The advantage of the instrument described is that it is almost completely insensitive to waveform distortion which may be introduced in the servo system under test, so that only the fundamental of the test frequency is taken into account in the plot computation. The instrument contains its own generator and provision for automatic running.

THE instrument has been built to satisfy the urgent need of a servo system design laboratory for an instrument giving a quick indication of the frequency response of a servo system, and also predicting its response under closed loop conditions. The instrument can also be used for determining the low frequency characteristics of electrical networks, transductors, or, in fact, of any device which is capable of accepting and producing a signal in the form of an electric voltage.



The complete response plotter

Though some Nyquist diagram plotters have been built[1,2], the instrument described here is the first to provide simultaneously both simple harmonic response and derived plots. An electro-mechanical analogue computor system is used, incorporating six servo mechanisms.

Test Frequency Generation

The test frequency voltage which is applied to the system under test is generated by a magslip driven with variable speed by a velodyne type motor-generator (see magslip 3 in "velocity servo" (Fig. 1). This magslip has a single-phase stator which is supplied with constant voltage from a carefully stabilized generator of carrier frequency which is in this case 2·4kc/s. The output from the rotor, which is also single-phase will therefore be:

$$E_1 \sin \omega_m t \sin \omega_c t \quad \ldots\ldots\ldots\ldots (1)$$

where ω_m is the radial velocity of the rotor corresponding to the test frequency.

$\omega_c = 2\pi\ 2400$ is the radial velocity of the carrier.

This voltage is then fed to a phase sensitive rectifier (P.S.R.5 on Fig. 1) and after rectification and filtering goes to an output d.c. amplifier and to the system under test. The output attenuator is used only for the initial output level adjustment.

The output signal:

$$E_1 \sin \omega_m t \quad \ldots\ldots\ldots\ldots\ldots (2)$$

is not dependent on the test frequency and remains constant throughout the test. This output voltage from the instrument, which is also the input voltage to the system under test is marked A_o on the vector diagram in Fig. 2.

Input Circuits

The output signal from the system under test which has now the amplitude E_o and is displaced in phase by angle α is accepted as an input to the instrument (vector A in Fig. 2). After passing through a d.c. cathode-follower, preset attenuator and a d.c. amplifier, this signal is used to modulate a 2·4kc/s carrier. The modulator circuit presented a considerable difficulty because of the high degree of accuracy required for the d.c./a.c. amplitude conversion, and by the need of keeping the phase-angle constant throughout the test frequency range. Obviously, any phase difference introduced at this stage would be detected by the sensitive resolver system which follows. Finally, a circuit utilizing the curvature of anode characteristics of two triodes in push-pull has been found satisfactory. Even so, the phase lag throughout this stage of the instrument, due to various causes, amounted to about 4° at 100c/s and a suitable phase-advance network has been incorporated to neutralize this effect.

Angle Resolving System

The basic principle underlying the action of resolving the angle and magnitude of a vector is explained in Fig. 1.

The signal received from the network under test, after modulation, is of the form:

$$E_o \sin (\omega_m t + \alpha) \sin \omega_c t \quad \ldots\ldots\ldots\ldots (3)$$

this voltage is then applied to the rotor of a magslip which is being driven by the same motor as the generator magslip 3 and is therefore rotating with velocity ω_m. The stator of this magslip is joined by a three-phase connexion to that of another stationary magslip (in "α servo", Fig. 1). The winding X of this magslip forms an angle ϕ with a datum line. Hence the voltage X will be:

$$X = E_o \sin (\omega_m t + \alpha) \sin \omega_c t \cos (\omega_m t + \phi) \quad \ldots\ldots (4)$$

$$\therefore X = \tfrac{1}{2} E_o [\sin (2\omega_m t + \alpha - \phi) + \sin (\alpha - \phi] \sin \omega_c t \ldots (5)$$

Hence it can be seen that, neglecting the carrier, the voltage will consist of a component of twice the test frequency

* *Winston Electronics Ltd.*

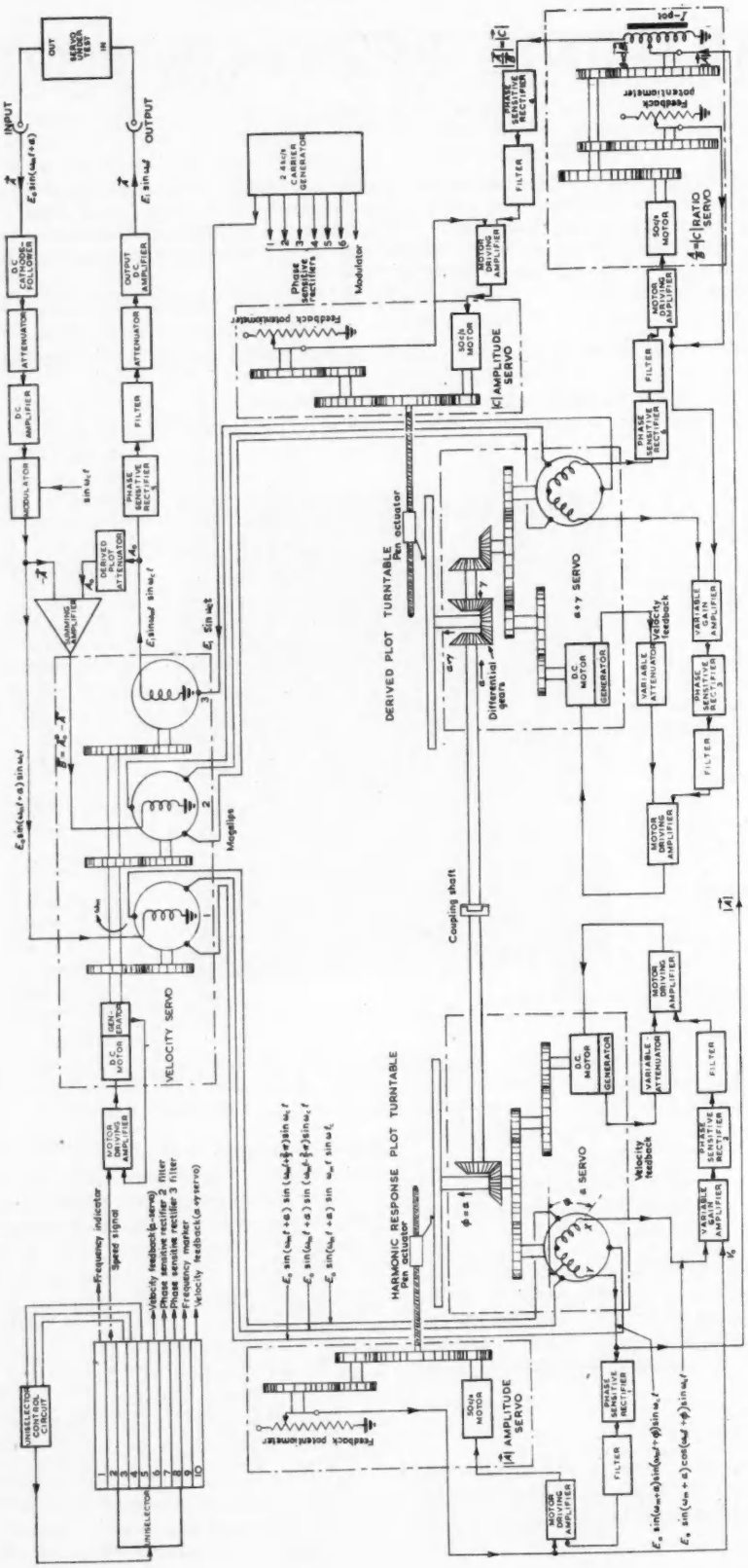


Fig. 1. Block diagram of the instrument

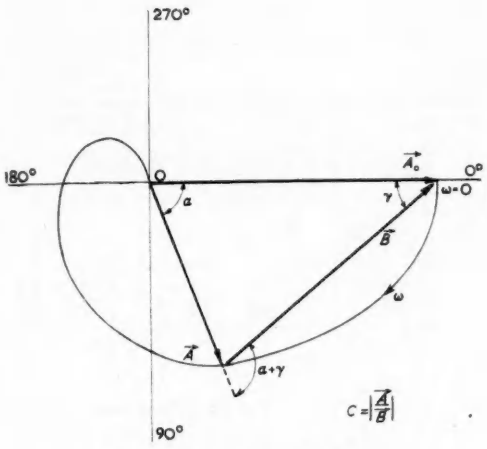


Fig. 2. Locus of the output vector

A_0 = input signal vector, A = output vector $\vec{B} = \vec{A_0} - \vec{A}$

plus a constant, which will, however, disappear if:

$$\sin(\alpha - \phi) = 0 \quad \ldots\ldots\ldots\ldots\ldots \quad (6)$$

i.e.:

$$\alpha = \phi \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

A servo which seeks a null position of this winding will therefore set the magslip shaft exactly at an angle corresponding to phase shift α. A turntable with the plot is coupled to the magslip shaft.

Assume now that the n^{th} harmonic of the test frequency of amplitude E_n is present in the output of the system under test due to distortion. Further, assume that the phase relation of this harmonic to the fundamental is represented by angle β. The expression (3) will now become:

$$[E_o \sin(\omega_m t + \alpha) + E_n \sin(n\omega_m t + \beta)] \sin \omega_c t \quad \ldots. \quad (8)$$

After this signal has been resolved in the magslip system as before, the voltage from winding X will be:

$$X = [E_o \sin(\omega_m t + \alpha) \cos(\omega_m t + \phi) + E_n \sin(n\omega_m t + \beta) \cos(\omega_m t + \phi)] \cdot \sin \omega_c t \quad \ldots\ldots\ldots\ldots \quad (9)$$

$$\therefore X = \tfrac{1}{2}\{E_o \sin(2\omega_m t + \alpha + \phi) + E_o \sin(\alpha - \phi) + E_n \sin[(n+1)\omega_m t + \beta + \phi] + E_n \sin[(n-1)\omega_m t + \beta - \phi]\} \sin \omega_c t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

By inspection, it can be seen that the only d.c. component (after removal of the carrier $\sin \omega_c t$) is the term $(E_o/2)\sin(\alpha - \phi)$. Therefore, the presence of harmonics in the waveform will not affect the computed angle ϕ.

Nulling Servo

The servo-mechanism used in the magslip resolver which was mentioned before represents rather a special problem. The nulling signal after rectification is of the form:

$$V = \tfrac{1}{2}E_o \sin(\alpha - \phi) \quad \ldots\ldots\ldots\ldots \quad (11)$$

First, it may be noticed that the amplitude of the signal to be resolved is variable over a range which in this instrument is 1:100. If a servo loop of constant gain were used, it would result in both low angular resolution for small values of K, and servo instability because of too high gain for large values of K. To prevent this, a variable gain amplifier (see Fig. 1) was inserted into the loop. The gain of this amplifier was made inversely proportional to a voltage V_a derived from the feedback potentiometer of servo A. This voltage is negative and proportional to the magnitude of vector A, i.e. to E_o.

The variable gain amplifier itself consists of two stages (see Fig. 3), the first of them a variable-mu pentode has the grid bias automatically adjusted to give the desired gain. The second valve is a conventional voltage amplifier.

The input resistor network is so arranged that the gain is the desired function of V_a, i.e.:

$$G = G_o/K \quad \ldots\ldots\ldots\ldots\ldots \quad (12)$$

Another difficulty encountered in this servo system was due to the signal ripple of frequency $2\omega_m$. For the lowest test frequency of 0·2c/s the servo would show a tendency to follow this ripple. To prevent this, an unusually large velocity damping has been applied. To avoid, however, a very slow servo response for higher frequencies, the velocity feedback is applied through an attenuator operated by the automatic switch coupled to the test frequency selector, which reduces the velocity feedback at the rate inversely proportional to the test frequency.

Amplitude Servo

The function of this servo is to plot the magnitude of the vector A (see Fig. 1). The required voltage is derived from the winding Y on the magslip resolver in the "α servo". This winding is at right-angles to the winding X and the output voltage, corresponding to equation (4) will therefore be:

$$Y = E_o \sin(\omega_m t + \alpha) \sin \omega_c t \sin(\omega_m t + \phi) \quad \ldots. \quad (13)$$

$$\therefore Y = \tfrac{1}{2}E_o [\cos(\alpha - \phi) - \cos(2\omega_m t + \alpha + \phi)] \sin \omega_c t \quad \ldots\ldots\ldots\ldots \quad (14)$$

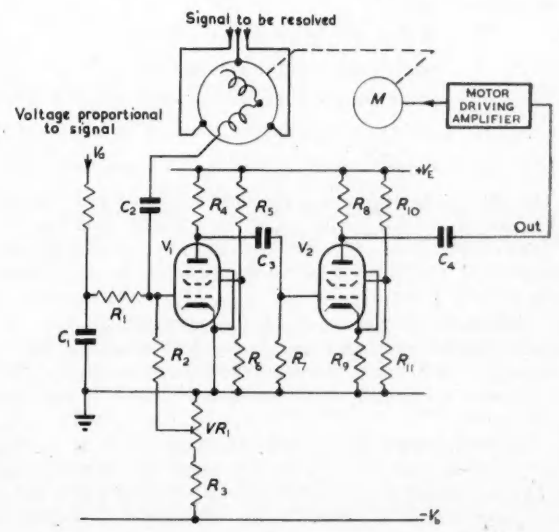
but from (7): $\alpha = \phi$

hence:

$$Y = \tfrac{1}{2}E_o [1 - \cos(2\omega_m t + 2\alpha)] \cdot \sin \omega_c t \quad \ldots. \quad (15)$$

After removal of the carrier component $\sin \omega_c t$ in the phase sensitive rectifier 1 (Fig. 1) a d.c. voltage is obtained with superimposed ripple of twice the test frequency. A filter which is used to smooth this ripple has the components automatically selected by the main test frequency

Fig. 3. Variable gain amplifier in a servo loop



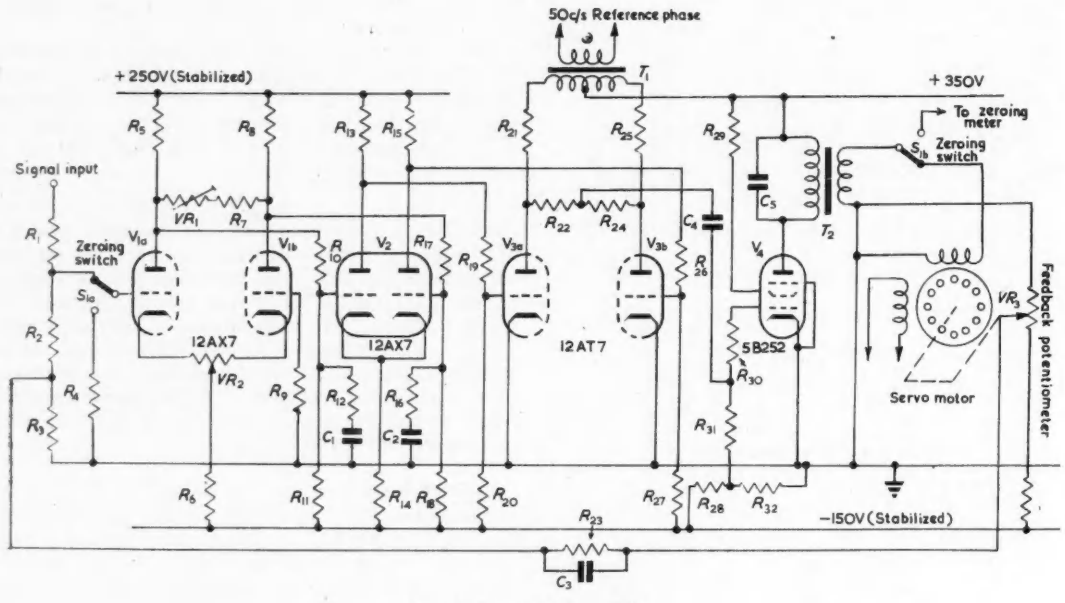


Fig. 4. Motor driving amplifier

selector. This voltage is fed into the "A amplitude servo" which is coupled by means of a lead screw to the writing pen above the graph paper. The motor driving amplifier is shown in Fig. 4.

The first two stages form a conventional d.c. amplifier with pre-set control VR_1 used for gain adjustment. V_3 is a very simple 50c/s modulator and V_4 an output stage which drives through a matching transformer an Evershed & Vignoles servo motor type FZ2/C. No velocity feedback is used because in view of a low inertia of moving parts the "self-stabilizing" characteristics of such a motor have been found sufficient to stabilize the system.

Derived Plot

Referring to Fig. 2, a graph of vector C and angle $\alpha + \gamma$ is required, where:

A_0 — is zero frequency or input voltage.

A — the output voltage at the test frequency.

B — is the difference between A_0 and A.

γ — the angle contained between A and B.

$$C = A'/B' = A/B\underline{|}\,\alpha + \gamma \quad \ldots\ldots\ldots (16)$$

(see Ref. 3, 4). To obtain the difference vector B, signals A_0 and A are fed to the summing amplifier (see Fig. 1). Both voltages are of modulated carrier form and can be applied to magslip 2, which is driven from the same shaft as magslip 1 and 3.

The resultant vector $A_0 - A$ is then resolved in exactly the same way as vector A. The derived plot turntable is driven through a differential gear from the harmonic response plot turntable so that the angle displayed is equal to the sum of α and γ.

To obtain the ratio of A/B, an I-pot driven by a servo ("A/B ratio servo" in Fig. 1) is used. The slider of the I-pot is moved to a position proportional to B and a signal of amplitude A is applied to it. The output, proportional to A/B is then used to position the pen on the derived plot turntable.

Control Circuit

The automatic action of the instrument is governed by the control circuit. It consists of a twenty-five position uniselector operated by a thyratron circuit and a four-position range-selecting switch. The functions of this unit are:—

(1) To provide a voltage proportional to test frequency which is fed into the velodyne driving the magslip generators. As the speed range of 500:1 is required in the instrument a simple two-speed gearbox is used, in which the gear change is achieved by the change of direction of rotation of the driving motor.

(2) To provide the variable time intervals, corresponding to the time required to stabilize the instrument at different frequencies.

Fig. 5. The two plotting tables

(3) To change filter constants.

(4) To adjust velocity feedback in servo 2 and 3, as mentioned before.

(5) To provide frequency markings in the form of short transients introduced to the pen drivers at each fifth step.

(6) To operate a visual frequency indicator.

It is possible to stop both plots at any time, for instance, on pressing of which the input to the amplifier becomes connected to earth and the output to the large centre-zero meter on the front panel.

Stabilized d.c. and heater supplies are available at the front panel of the instrument for connexion of any auxiliary apparatus.

Performance

The angular accuracy of both plots is 2°; the magnitude

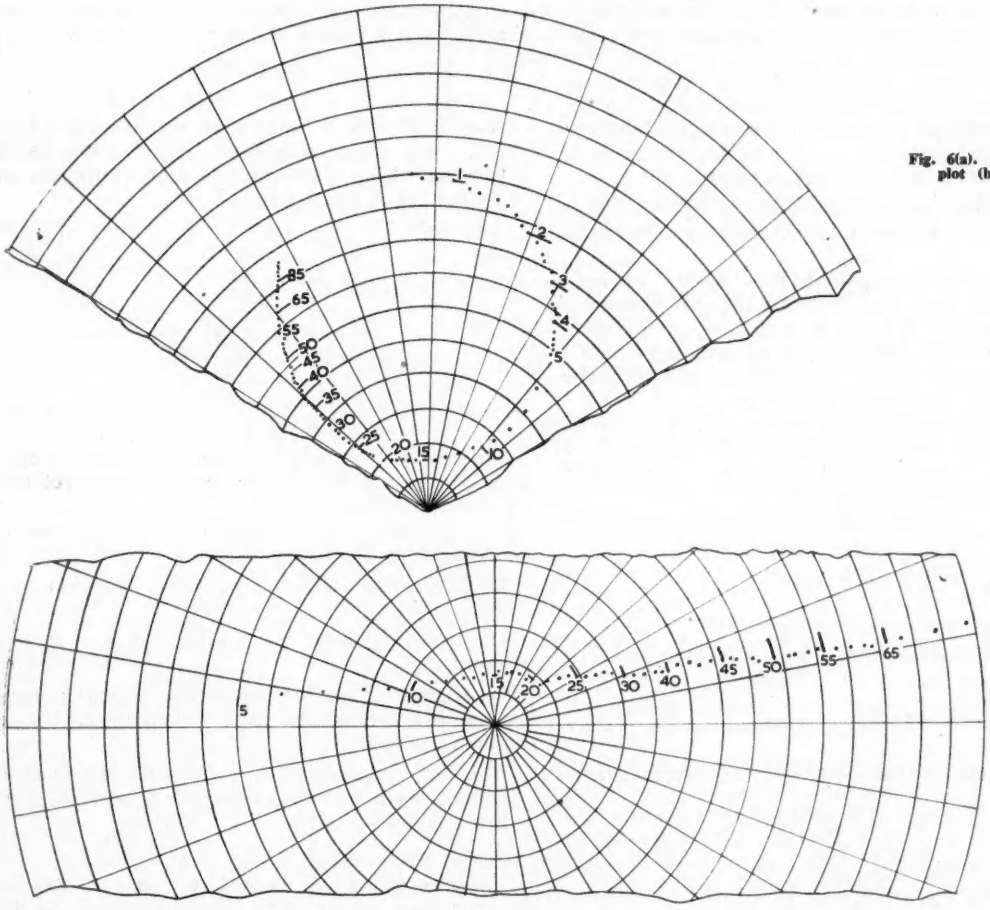


Fig. 6(a). Harmonic response plot (b) Derived plot

to see what effect the change of some constants in the servo under test has on the plots.

Layout and Construction

The instrument is housed in a double 19in rack 4ft 4in high. Both plotting tables, to take 30cm polar diagram paper, are mounted on top (Fig. 5). A pen is moved across the table by a lead screw. The pens are normally not in contact with the paper and are actuated only when the instrument changes to a new frequency so that the plot is obtained in the form of a series of dots and dashes marking each fifth frequency step. At the back access is available to a number of tags situated on the chassis and interconnecting cableforms, thus facilitating fault finding.

All amplifiers are provided with spring-loaded switches

accuracy is ± 2 per cent for the harmonic response plot and ± 3 per cent for the derived plot.

Two specimen diagrams are shown in Fig. 6. These were obtained with a bridged-*T* filter, used as a test network.

Acknowledgments

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REFERENCES

1. Harmonic Response Testing Apparatus. R.A.E. Report EL.1479.
2. Nyquist Diagram Plotter. *J. Sci. Instrum.* (Sept., 1952).
3. Electronic Instruments. Ch. 10 (M.I.T. Radiation Laboratory Series, Vol. 21).
4. MacColl, L. A. Fundamental Theory of Servomechanisms.

An Outline of

An Electronic Arithmetic Unit

By W. Woods-Hill*,

Since the first acceptance of electronic calculators into the business world, the call has been for greater reliability and a means of automatically checking calculations. The need is greater in electronic machines than in their mechanical counterpart because of the very much greater output per unit-time. In this article an electronic arithmetic unit is described and a method of checking calculations is detailed.

AN arithmetic unit was required which could perform at least the following:

$$A \times B \pm D = C \text{ and check.}$$

The "and check" indicates that the calculation must be verified and proved correct before the answer leaves the machine.

The factors were to be supplied from punched holes in a Hollerith card in decimal form and the answer punched back into the same card also in decimal.

The cards were to feed at 100 per minute (on a Type 237 Gang Punch), and the time available for the calculation was the gap between cards, i.e. 90msec.

The system of multiplication used is interesting, and for obvious reasons called "Doubling and Halving." To multiply 7 × 3, set up the 7 and halve it consecutively, discarding anything less than one,

i.e.

	7
$\frac{7}{2} = 3(\cdot 5)$	3
$\frac{3}{2} = 1(\cdot 5)$	1
$\frac{1}{2} = 0(\cdot 5)$	0

then set up the 3 beside it and double it consecutively,

i.e.

7	3
3	6 (= 3 × 2)
1	12 (= 6 × 2)
0	24 (= 12 × 2)

Now inspect the digits in the left-hand column, starting at the top, and every time the digit is an odd number, take the digit in the right-hand column and put it down. Add up this new column,

i.e.

7 odd	3	3
3 odd	6	6
1 odd	12	12
0 even	24	
		21

i.e. $7 \times 3 = 21$

"0" is looked upon as an even number. This will work with any notation, including £ s. d., and is why it is used here.

* *The British Tabulating Machine Co. Ltd.*

Those familiar with binary code will realize that this is simply a way of extracting the binary terms in a decimal number and doing binary multiplication by column shift in the scale of 2. For example:

$7 \times 3 = 21$

7 =	111
3 =	011
	111
	111
	000
	10101 = 21

i.e. $16 + 0 + 4 + 0 + 1 = 21$

The great point to be got out of all this is that to double or halve a number expressed in binary requires but a shift of one binary place.

We have here the five components needed to make a multiplier (Fig. 1).

(1) Register *A* holds the multiplier numbers to be halved.

(2) Register *B* holds the multiplicand numbers to be doubled.

(3) Register *C* receives the product numbers from *B* before they are doubled, and by means of box ADD accumulates them.

The fifth component is the O.E.D. box (odd-even detector), which only allows numbers to go from *B* to *C* when *A* is odd.

Shifting Registers

Consider register *B*. Each square in Fig. 2(a) is an Eccles-Jordan trigger. The values allocated to these triggers are 8, 4, 2, 1 across the top (*X* axis) and units—hundreds—thousands—etc. up the side (*Y* axis).

That means that the number 325 would be written:

	8421
3 =	0011
2 =	0010
5 =	0101

In the register it would cause the triggers marked *X* (Fig. 2(a)) to be ON and all the rest OFF. (Note that the pattern is the same as the binary equivalent above.)

Now register *B* (like *A* and *C*) is a "shifting register." That is to say, a single pulse applied to all the triggers together will cause the "pattern" representing 325 to shift down one place along the *Y* axis, so that the "5" drops

off the end, and the "3" and the "2" move down one place.

The number now reads 32 (Fig. 2(b)). If four connexions had been made from the bottom to the top of the register (one to each binary column), then the "5" would not have been lost but would have "fed back" and appeared at the top. (Fig. 2(c).)

Thus, if the right number of pulses were applied to the register (in this case 10), the pattern representing 325 would have moved right round the register, one step per

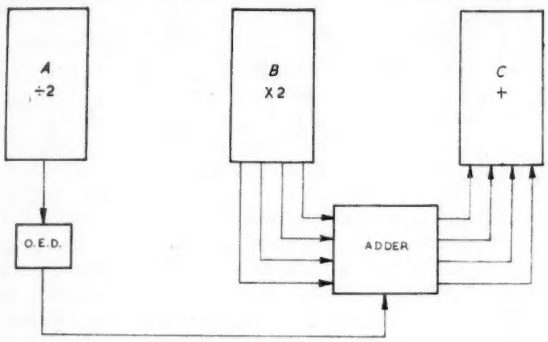


Fig. 1. Basis of multiplier

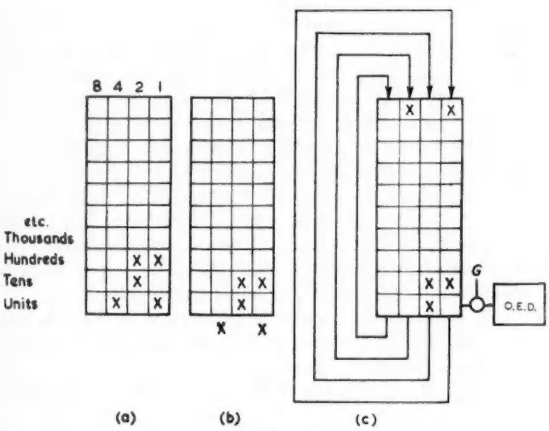


Fig. 2. Shifting registers

pulse, to come back to its starting position. The system of presenting numbers just described is known as "sequential parallel."

TRANSFER

To transfer a number from register *B* to register *C*, one simply needs to take four connexions across and couple them to *C*'s feedback loop.

Pulsing both registers through one cycle (10 pulses) will cause the number 325 to appear in register *C* while still retaining it unchanged in *B*.

This is, of course, due to *C* being unable to distinguish between a stimulation from another register and its own feedback loop.

If the registers are cycled again, nothing further will occur and 325 will simply circulate round both registers.

If it is required to repeatedly add 325 to *C* from *B* so that after each cycle it reads:

325
650 (+325)
975 (+325)
etc.

then an ADDER must be inserted into the transfer connexions. This is the fourth component in Fig. 1, and will be described later.

O.E.D.

Component five, the O.E.D. (odd-even detector), is a very simple device doing just what its name implies, and consists of nothing more than a trigger connected by a gate (*G*) (Fig. 2(c)) to the lowest binary-decimal position of the register *A* in such a way that if the "1" trigger of the "units" denomination is "on" the O.E.D. will also come on. This will only occur, of course, if gate *G* is momentarily opened.

It can be shown that if ever this "1" trigger is ON when a number is resting in its "at home" position, then

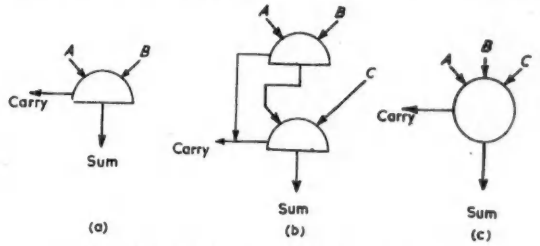


Fig. 3. A half adder, two half adders and an adder

that whole number is odd. Example:

8 = binary 1000 = even
5 = binary 0101 = odd.

Therefore opening gate *G* at the correct time will cause the O.E.D. to "remember" if the number was odd or even. The voltage from this O.E.D. trigger is used to prevent, or allow, transfer (from *B* to *C*, Fig. 1).

COMPONENT 4: THE FULL ADDER

The full adder is built up of a series of adders which in turn consist of two ½ adders. This adder (Fig. 3(a)) must be capable of doing the following binary addition:

	A		*B*		SUM	CARRY
Binary	0	+	0	=	0	0
„	1	+	0	=	1	→ 0
„	0	+	1	=	1	→ 0
„	1	+	1	=	0	→ 1

and can handle two inputs *A* and *B*. If a third input is to be handled (incident carry) then two ½ adders in cascade can be used connected as shown (Fig. 3(b)). This will handle:

A		*B*		*C*		SUM	CARRY
0	+	0	+	0	=	0	→ 0
0	+	0	+	1	=	1	→ 0
1	+	0	+	1	=	0	→ 1
0	+	1	+	1	=	0	→ 1
1	+	1	+	1	=	1	→ 1

or any permutation of *A*, *B* and *C* to give these answers. An adder (2 × ½ adder) is abbreviated to Fig. 3(c) for simplicity.

If it is wished to add two numbers from register *B* and *C* and put the resultant back into *C*, then it will be necessary to handle four pairs of binary inputs, four outputs (sums) and a grand carry.

How this is done is shown in Fig. 4. C.M. is the Carry Memory Trigger needed to store a grand carry. A grand carry, of course, is a carry between vertical-denominations requiring a digit time delay, as against a horizontal binary carry requiring no delay.

The four adders receive the four possible pairs of inputs simultaneously, sums them, and sets a carry if the sum exceeds 16.

The device, as it is, would be excellent to handle numbers in the scale of 16 but quite useless for the scale of 10, the main trouble being that the carry occurs at 16 instead of 10. This can be solved by building a "10 or more" detector which would stimulate a false carry as soon as a sum greater than 10 was produced by the incident digits. This is quite simple, and consists of a ½ adder connected to the sum line value 8, 4 and 2 (Fig. 4), so that if the sum contains an 8 and a 2, or an 8 and a 4, or an 8 and a 4 and a 2 (these are the only combinations which can exceed 10), then the carry bussbar (Fig. 4) is stimulated.

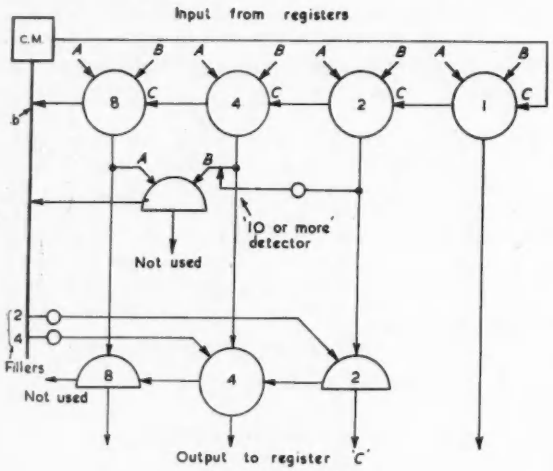


Fig. 4. A full adder

This solves the carry problem and will cause a "1" to be put in the next denomination higher (later), but this denomination now has a value of 10 by stipulation and the carry was stimulated by any number between 10 and 16.

If it can be arranged to "pay back 6" into the present denomination at the same time as storing a carry for the next, then the conditions will have been fulfilled and a carry will indeed be worth 10.

This is done by inserting a further bank of adders in the SUM lines 2s, 4s, 8s, (Fig. 4) and causing the carry bussbar to stimulate a 2 and a 4 filler input to these every time it is energized. This causes 6 to be added to whatever the sum lines were showing.

For example, 5 + 8 = 13, "Greater than 10 detector" stimulates carry bussbar, carry bussbar sets carry memory and causes 4 and 2 (6) to be added to the sum lines via a second bank of adders, i.e. 13+6=19. 19 in the scale of 16 is 3 and a carry: this second carry is lost (not connected). Net result: 5 + 8 = 3 → 1 carried.

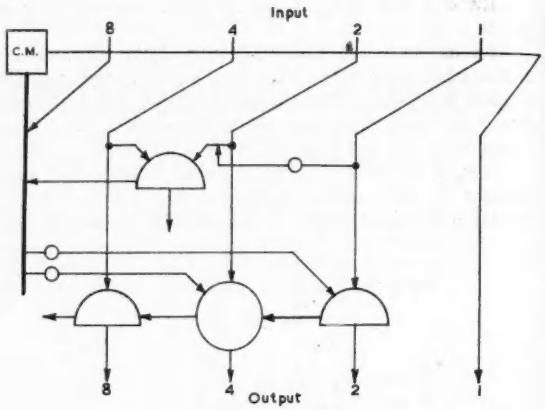


Fig. 5. A doubler

All this may sound rather laborious, but due to the d.c. nature of the ½ adders all is over in less than ½ a pulse time. It should be noted that some of the adders in the second bank are only receiving two inputs and are therefore only ½ adders. The largest incident digits to this full adder would be 9 + 9 = 18.

DOUBLER

As previously mentioned, to double a number expressed in binary one needs but to shift one place to the left; i.e. binary 0011 = 3, shift one left: binary 0110 = 6. Therefore, if in register *B* the feedback loops were misconnected so that the 1 fed back to the 2, the 2 to the 4, the 4 to the 8, the 8 to a carry memory, then the number would be doubled simply by applying 10 pulses to cycle it. Unfortunately, the carry is in the scale of 16 and all the remarks about numbers exceeding 10 applicable to the full adder apply here and the same circuits must be used, but this time in the feedback loop. Fortunately, the bulk of the circuits (the first bank of adders) can be left out because there is only one set of incident digits, not two.

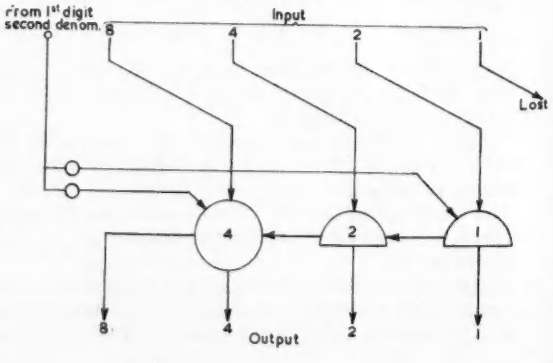
Fig. 5 shows the same sort of circuits as the full adder with the first bank missing and the input wires crossed to the left to produce doubling.

The largest incident digit to be doubled would be 9 × 2 = 18.

HALVER

To halve, simply cross the connexions to the right

Fig. 6. A halver



(Fig. 6). There is no need for rationalizing circuits because no number halved can exceed 9.

One bank of adders is required, however, because halving an odd number (this means any individual denomination, not the whole number) necessitates the adding of 5 into the denomination below. Example:

$$\frac{50}{2} = 2(5) \text{ in binary/ten.}$$

Second Denom. 0101 = |5| | | ÷ 2 = 0010 = |2| |

First Denom. 000 = | |0| | = 0101 = | |5|

This infers a carry of 5 downwards every time a binary digit is detected in the 1s column of the second denomination. As shown in Fig. 6, this is achieved by tying a detector to this digit which, when energized, causes 4 and 1 to be added via the adders to the denomination being fed back, after it was halved, i.e., beyond the point where the connexions cross.

MULTIPLICATION $A \times B$

At this point we can elaborate on Fig. 1 and follow the sequence of events when multiplying $9 \times 4 = 36$. In Fig. 7, the 9 is standing in the multiplier register A, 4 in the multiplicand B, and the product register C is empty. By momentarily opening G_1, the O.E.D. can be set or unset before each cycle. All registers are pulsed together 10 times each cycle. Before the start of each cycle the registers will look like this:

REGISTER	A	B	C	
Cycle 1	9	4	0	odd transfer
,, 2	4	8	4	even
,, 3	2	16	4	even
,, 4	1	32	4	odd transfer
,, 5	0	64	36	even
,, 6	0	128	36	even
etc.	etc.	etc.	etc.	etc.

The following is the state of the binary patterns at the end of each cycle, showing in more detail what happens during each cycle.

	A	B	C
1	(9) 1001	(4) 0100	(0) 0000

Test A for odd-even by gate G_1. Odd, so O.E.D. sets and opens gate G_2 (B to C): cycle once.

	A	B	C
2	(4) 0100	(8) 1000	(4) 0100

Test A. Even, so O.E.D. unsets. Gate G_2 closed: cycle once.

	A	B	C
3	(2) 0010 (16)	(1) 0001 (6) 0110	(4) 0100

Test A: even. O.E.D. stays unset. G_2 closed: cycle once.

	A	B	C
4	(1) 001 (32)	(3) 0011 (2) 0010	(4) 0100

Test A: odd. O.E.D. set. G_2 opens: cycle once.

	A	B	C
5	(0) 0000 (64)	(6) 0110 (4) 0100	(3) 0011 (36) (6) 0110

Test A: even. O.E.D. unset. G_2 closed.

(The numbers in parentheses are the decimal equivalent of the binary numbers.)

Any further cycling of the machine after A has reached zero cannot affect C as G_2 never opens again.

It is obvious from the above that the length of time taken to multiply a number will be governed by the size of the multiplier (A) and quite independent of the multiplicand (B). As a matter of interest, the number of cycles required to ensure that a 10-digit number reading all 9's is "halved" below "1" is 36. The length of time it will take, therefore, to multiply 10 digits by 10 digits to give a 20 decimal digit answer is 18msec with a pulse repetition rate of 20kc/s. These 20 digits exceed the capacity of the counter C described, and is of academic interest only.

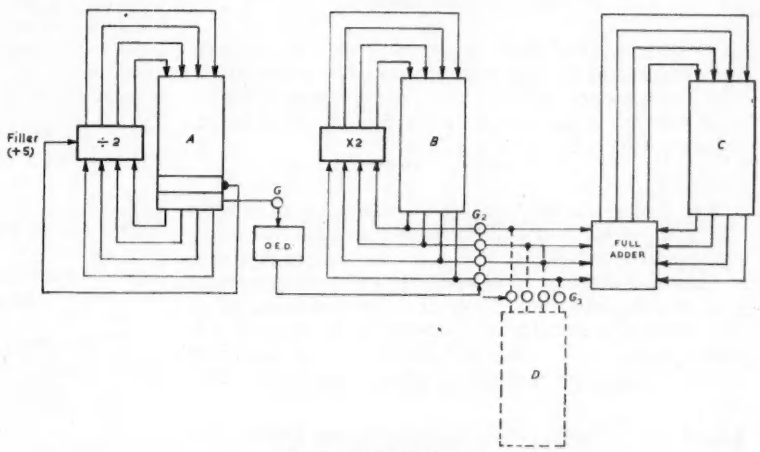


Fig. 7. An arithmetic unit

Circuits

The three basic circuits used are:

(1) The Shifting Register[1],

(2) The Gate, and

(3) The Half Adder.

(1) SHIFTING REGISTER

Fig. 8 shows two stages of a shifting register V_1 and V_2. MR_1 and MR_2 are two diode gates connected to the left-hand and right-hand anodes of trigger V_1. If V_1 is 'on,' then gate MR_1 is primed; if V_1 is 'off,' gate MR_2 is primed. MR_1 is connected to the input of V_2 trigger so that a pulse through it will set V_2, and MR_2 will unset V_2. Pulsing the common pulse line P will therefore cause V_2 to assume whatever state V_1 might be. V_2 itself will influence V_3, and V_3 will influence V_4, and so on.

Thus any trigger will be made to assume the state of

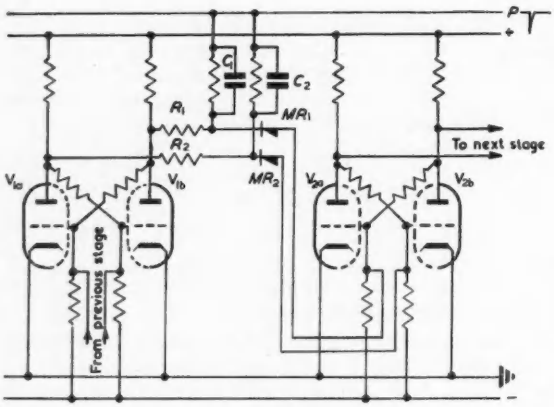


Fig. 8. A shifting register

its predecessor. The fact that any stage may be changing while influencing the next is taken care of by the relatively long time-constant made by R_1C_1, R_2C_2, "remembering" what state the trigger was in for the duration of the action pulse (5μsec).

(2) GATE

Fig. 9 shows a pentode gate connected to a trigger. The grid voltage of a trigger varies between $+2 - 30$V, depending upon whether it is 'on' or 'off' respectively.

The anode voltage of the pentode will not vary, whatever state the grid is in, as long as -30V is maintained on the suppressor. Bringing the suppressor up to earth will allow electrons to reach the anode and an amplified inverted version of the grid condition will appear thus, i.e.

Grid Voltage	Anode (supp. +2) Voltage	Anode (supp. −30) Voltage
+2	+50	+160
−30	+160	+160

One trigger connected to the suppressors of four pentodes can therefore control the four output lines of a register.

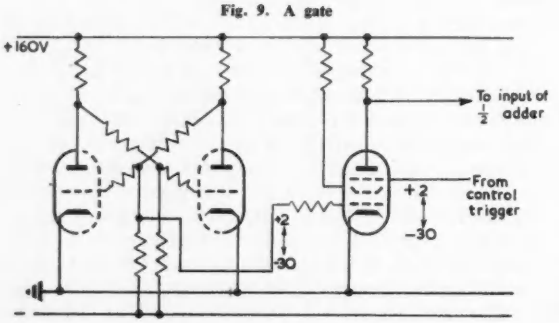
(3) HALF ADDER

A digit in this machine is a fall in voltage from +160 to +50V (negative going 110V swing). Because these ½ adders are to be connected in chains, their outputs must be of the same polarity and swing as their input requirements.

How this is done is shown in Fig. 10.

With no incident digit (i.e. A and B at +160V), both

Fig. 9. A gate



halves of V_1 are conducting heavily because both grids are trying to go positive. Both anode voltages are therefore low, and when this condition is transmitted to V_3, an invertor, via R_1R_2 and R_3R_4, results in V_3's grids being negative. Both invertor anodes are therefore cut off and at a high voltage (= 0), i.e.

A		B		SUM	CARRY
0	+	0	=	0	→ 0

With one incident digit $A = +50$V, $B = +160$V; the grid of V_{1a} is cut off, because it is near the negative end of the voltage divider, but V_{1a} is still positive and its anode therefore still low. This one anode low and one high condition of V_1 is interpreted at the invertor V_3 anodes as a low "sum" +50 and a high "carry" +160, i.e. 1 + 0 = 1 → 0.

With two incident digits (A and $B = +50$ V), both grids of V_1 are cut off and both its anodes should be high, but V_2 anode is also coupled to V_{1b} anode, and because V_2 under these conditions is conducting, this latter anode will remain low and clamp V_{1b}. This condition is interpreted by the invertor as "sum" high +160 and "carry" low +50, i.e. 1 + 1 = 0 → 1.

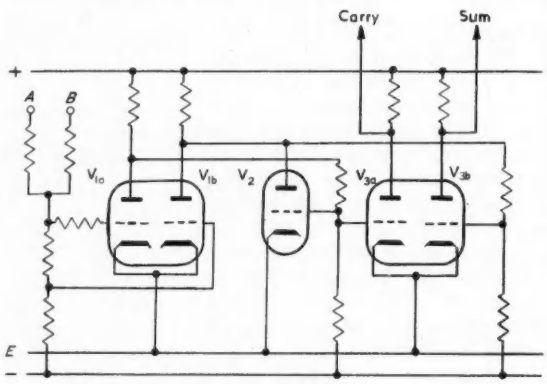


Fig. 10. A half adder

Why V_2 should choose to clamp V_{1b} anode under these conditions is because its grid (V_2) has been connected by a voltage divider chain R_5R_6 to V_{1a} anode, which until this moment has always been low, maintaining the grid of V_2 below cut-off.

The interesting thing about these adders is that they are entirely d.c. connected, so that statically inserting dummy digits at the input of the full adder (causing the voltage to fall from +160 to +50V) one can inspect the output by means of neons connected for the purpose; this enables a check to be done with the machine at rest and see that the adder is doing its sums correctly.

(4) ± D REGISTER

If a further register D (shown dotted Fig. 7) is added and connected by gates (G_3) under separate control to the input of the full adder, then when multiplication is finished the contents of D can be "rolled" on top of the product standing in C by simply opening G_2 and cycling once.

D can be subtracted from C by setting D up in complement and doing as above.

"AND CHECK"

The system of checking to be described is applicable to any arithmetic unit capable of multiplication, and will

be described in general terms without reference to this sequential parallel machine.

Basically it involves doing the multiplication twice and comparing the two results to see if they agree. This in itself is of no great value because a fault (such as an open-circuit heater) will produce the same wrong answer both times and agree.

On the other hand, if the factors to be multiplied are altered in some way the second time, some way which will produce the same product and yet cause the machine to go through a different routine to get there, then a fault such as mentioned will produce a wrong answer both times, but the wrong answer the second time will not be the same as the first and will therefore not agree.

One system proposed used "factor reversal," i.e. exchange the number in the multiplier for that of the multiplicand. This falls down if the two factors happened to be the same, say 4444 × 4444, and anyway cannot be used if the scales of notation are different, 33·7 × £9 19 11. Some systems do not deal with the arithmetic of the machine, but concentrate on checking the digits in the counters: even or odd summing of the digits within counters; biquinary (always two elements must be in use); automatic periodic zero test; pilot multiplication. This last is really a periodic arithmetic check.

All these give some measure of safeguard, but very few, if any, are capable of checking to see if the answer is right *after it has been punched out.*

Stress is laid on this because one of the major sources of non-repetitive faults can be traced to the coupling of the electronic portion to the output organ.

The mysterious quality of some of these faults can be readily understood when the relative speeds of the two machines are compared — electronic equipment and mechanical card feed.

The electronics might repeat a duty cycle 1 000 times in one second, so that a marginal fault will reappear quite quickly.

A mechanical device will take many minutes, if not hours, to do 1 000 passages; and if, as is quite often the case, a combination set of circumstances is required between electronic and mechanical to produce the fault, it may come once and never return. Further, a one-thousandth of an inch unexpected movement on a cam may equal 5 or more complete pulse times of the electronics, and thereby make the same fault produce different evidence each time.

To try to take care of all these factors, the following system was developed.

The factors are read from the card twice: once as the card enters the machine and once as it leaves. Two completely separate sensing mechanisms (brushes) and paths are provided to the electronic portion. The first time, the arithmetic operation is done quite normally, and the answer punched out in the card, and not retained. As the card leaves the machine, it is sensed once again and the factors are read back again to the electronic portion *along with the answer just punched.*

The arithmetic operation is checked by doing the multiplication again, but this time the multiplier factor is increased by a factor of 10 (col. shift up once) and the multiplicand decreased by a factor of 10 (col. shift down) to compensate, and in that way give the same correct answer as the first time. This infers a means of dividing by 10 if the multiplicand factor is expressed in a non-decimal scale, i.e. £ s. d., T. Cwt. Qrts.

The first answer just picked up off the card is now compared with this new answer (by rolling in complement and adding "one"), and if they agree the card is allowed to drop into the hopper.

The following example will help to illustrate how the machine handles this check.

Take the case previously mentioned of 4444 × 4444. This now looks like this: 44440 × 0444·4, and gives the same correct answer.

Suppose it had a fault in counter three and read in like this:

First Multiplication:	*A* 04444	×	4344·0	= 19304736
Second Multiplication:	*B* 44440	×	0344·4	= 15205136

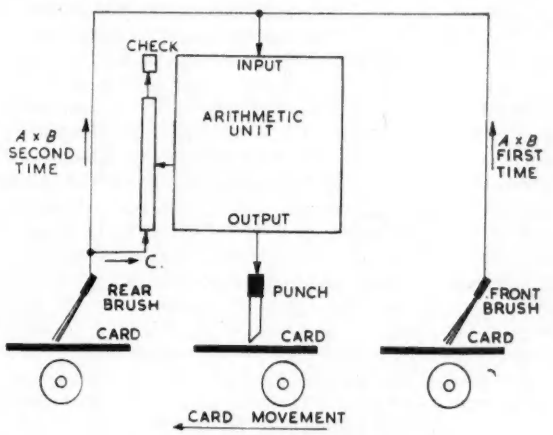


Fig. 11. A print unit ($A \times B = C$ *and check*)

Line *A* does not give the same answer as line *B* and would not check even though the fault is consistent.

Supposing the fault was more subtle, and consisted of a faulty transfer during multiplication on one cycle only, or where there was a special combination of numbers in the multiplicand, or both.

The multiplier is repeatedly halved, and would halve (on the second run) quite differently than it did the first. It would require more cycles (it is now a 5-digit number) and the transfers will occur on different cycles; further, the multiplicand doubling up is doubling from different counters, which in all leaves very little chance for compensating errors.

Finally, when £ s. d. are used, because a tenth of, say, £1 11s. 1d. is 3s. 1·3d., the number in the multiplicand counter bears no resemblance to the one used in the first multiplication.

The same principles could be applied to a print unit by signalling back from the type bars.

The block schematic of such a machine is shown in Fig. 11.

Acknowledgments

The author wishes to offer his thanks to Mr. L. Knight, Mr. A. Trussell, and the members of the Electronic Laboratory, for their contributions to this project, and The British Tabulating Machine Company Limited for permission to publish this article.

REFERENCE

1. Booth, A. D., Booth, K. H. V. Automatic Digital Calculators (Butterworth's Scientific Publications Ltd., 1953).

The Display of Transformer Magnetizing Ampere-Turns on a Cathode-Ray Oscilloscope

By M. E. Bond*

If in a transformer the current is not sinusoidal, or if the working conditions are altered by disconnecting the associated circuits, then the normal method of finding the magnetizing ampere-turns is not satisfactory. In this method, small resistors proportional to the number of turns are placed in series with each winding. The resultant voltages are then correctly mixed and displayed on a cathode-ray oscillograph. The application of this method to the line output transformer of a television receiver is described.

IT is often desired to measure the operating conditions of a transformer core. To achieve this it is necessary to measure the magnetizing ampere-turns, various physical constants, and have a knowledge of the *BH* curve of the material concerned. When the magnetization is sinusoidal, the magnetizing ampere-turns are normally found by direct measurement of the no-load current through the transformer. If, due to overloading or a non-sinusoidal applied voltage, the current is not sinusoidal, or if the current under working conditions has a waveform different from that of the no-load condition, then it is necessary to measure the magnetizing ampere-turns by taking the difference of the instantaneous ampere-turns in each winding at many points during the cycle and reconstituting graphically the magnetizing ampere-turns cycle. This involves the measurement of the separate current waveforms in each winding and accurately determining their relative time relationship. The resultant magnetizing ampere-turns can then be calculated and plotted. An easier method is to arrange for the direct display of the magnetizing ampere-turns on a cathode-ray oscillograph.

Consider a transformer with several secondary windings. The instantaneous primary current is i_1 and the instantaneous currents in the other windings are i_2, i_3, etc., respectively. The number of turns on each winding is N_1, N_2, N_3, and so on.

Then the magnetizing ampere-turns =

$$N_1 i_1 - (N_2 i_2 + N_3 i_3 + \ldots .) \ldots \ldots \ldots \quad (1)$$

If a small series resistor is placed in each circuit, then the voltage across these resistors will depend on the value of the resistance and the current flowing. The resistors in each circuit are chosen so that the resistance is proportional to the number of turns, thus (see Fig. 1):

$$N_1 = KR_1 \qquad N_2 = KR_2 \qquad N_3 = KR_3 \qquad \text{etc.}$$

The voltage developed across each resistor will then depend on the current flowing and the constant K,

$$v = iR$$

$$= \frac{iN}{K}$$

or $iN = vK$ where K is expressed in turns per ohm. So that the equation (1) can now be rewritten:

Magnetizing ampere-turns $= (v_1 - v_2 - v_3 - \ldots .)K$

Thus if these four voltages can be mixed, the resultant, when multiplied by K, will equal the magnetizing ampere-turns. It is essential for this that one side of each winding should be earthy and that the right phasing of each voltage is obtained, the voltage from the primary being in opposite phase to those from the secondary. This can often be arranged by inserting the resistors where either the winding or its load is connected to earth. The voltages are mixed by applying them to a network of carefully matched resistors (Fig. 2).

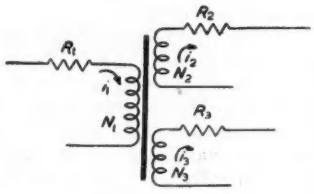


Fig. 1. Transformer with series resistors

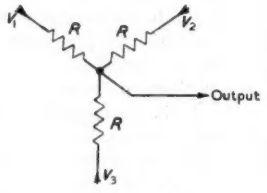


Fig. 2. Mixing circuit

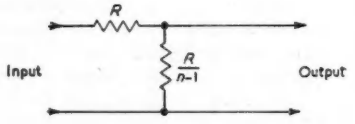


Fig. 3. Circuit seen by each input

If these resistors R are very much larger than R_1, R_2, R_3, etc., then for each input the circuit approximates to Fig. 3.

Thus the voltage fed to the oscilloscope $= V/n$ where n is the number of windings and $V = (V_1 - V_2 - V_3 - \ldots .)$.

Hence the magnetizing ampere-turns $= Vnk$ where n and K are known and V can be measured on the oscilloscope tube face.

Where direct instead of a.c. coupling to the oscilloscope is possible, the input to the oscilloscope can be shorted intermittently to show zero level as a horizontal line on the tube face.

* *Philips Electrical Ltd.*

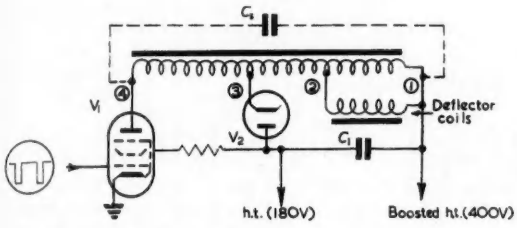


Fig. 4. Basic circuit of television receiver line output stage

This method has been used to find the operating conditions of the ferroxcube core of the line output transformer of a television receiver.

Basically the circuit is as shown in Fig. 4.

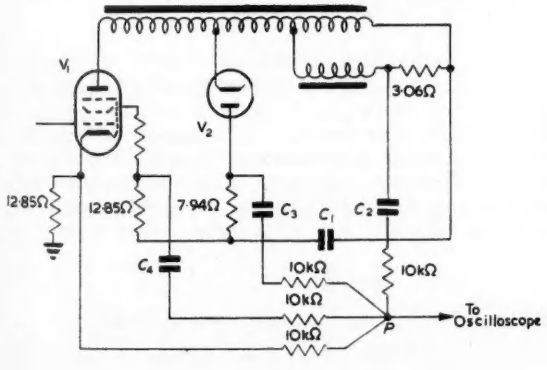
The waveform applied to the control grid of valve V_1 switches this valve on or off. When the valve is switched on, a current flows through it and the transformer so that a potential difference exists across the transformer. The tap (3) does not fall below the h.t. line potential, and a reasonably steady voltage exists across the transformer during this period. This causes an exponentially increasing current to flow through the deflector coils.

When V_1 is made non-conducting, the current then flowing in the circuit charges C_s the self-capacitance, to a very high voltage opposite in direction to the original voltage across the transformer, raising point (4) to a very high positive potential. The current through the deflector coils changes direction very rapidly.

C_s now starts to discharge in an oscillatory manner through the transformer. The potential at (4) drops rapidly until (3) is negative relative to the h.t. line. Valve V_2 then conducts and clamps (3) at the h.t. voltage, causing point (1) to rise to a voltage higher than that of the h.t. line. C_1 is thereby charged. When the charge from C_s has been transferred to C_1, V_1 is again switched on and maintains the voltage gradient across the transformer. The current through the deflector coils increases exponentially from its negative peak at the end of the flyback to provide the receiver line scan. The whole process is repeated at a frequency of the order of 10kc/s.

This has only described the basic principles of the circuit. In practice the circuit would be modified, for instance, to provide a linear and not an exponential scanning current. It has shown that no part of the circuit can be disconnected without materially affecting its working. Measurement of the core working conditions cannot therefore be made in the normal way.

Fig. 5. Circuit adapted for measuring magnetizing ampere-turns



From the winding data it is found that section (1) to (2), (N_1), of the transformer has 180 turns, section (1) to (3), (N_2), has 470 turns, and section (1) to (4), (N_3), has 720 turns. It has also been found by experiment that the maximum resistance that can be added to the deflector coil circuit without appreciably altering its working is of the order of 3Ω. Another difficulty is that V_1 anode current waveform is not readily available. This can, however, be obtained by subtracting the screen waveform from the cathode waveform in the same manner as the transformer magnetizing ampere-turn waveforms would be subtracted.

If $N_1 = 180$t and a resistor of 3·06Ω is inserted in this circuit, then $K = 59{\cdot}2$ turns per ohm

so that $R_2 = N_2/K = 7{\cdot}94\Omega$

and $R_3 = N_3/K = 12{\cdot}85\Omega$.

These are connected in the circuit as shown (Fig. 5). The mixing resistors are 10kΩ because this value is of the order of 1 000 times R_1, R_2 and R_3, but is not high

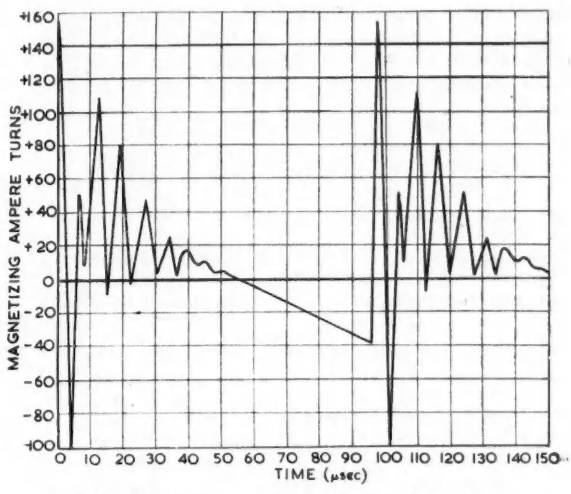


Fig. 6. Magnetizing ampere-turns of line output transformer

enough with the stray capacitances to limit the upper frequency response of the oscilloscope input circuit. Capacitors C_2, C_3 and C_4 are included to isolate the oscilloscope from the direct h.t. and boosted h.t. voltages.

The sensitivity of the oscilloscope reckoned in r.m.s. sine wave values is 0·1V/cm. Thus the scale for magnetizing ampere-turns is:

$$0{\cdot}1 \times 2\sqrt{2} \times 4 \times 59{\cdot}2 = 67 \text{ ampere-turns/cm.}$$

The oscilloscope time-base is synchronized with the television line scan waveform. A drawing of the results is shown (Fig. 6), and from this the operating conditions of the ferroxcube core can easily be determined. In this case much tedious work is saved by using this method, as the accurate relative time location of the several peaks in the waveforms and their subsequent subtraction would be very difficult.

Acknowledgments

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The Tapped Bridged-T Rejector

By D. J. S. Westwood*, B.Sc.

Two forms of tapped bridged-T rejectors are developed. The balance equations are determined in each case and approximations applied to reduce the solutions for practical use. By differentiation of certain equations the maximum values of the balancing resistors are established.

IN television receiver practice the tapped tuned circuit rejector shown in Fig. 1(a) is often used in series with coupling elements in i.f. or r.f. amplifiers to obtain rejection of the sound or adjacent sound channel. The symmetrical bridged-*T* rejector shown in Fig. 1(b) is also occasionally used. The inherent resistances of the coils in Fig. 1 are omitted for simplicity in the diagrams. It is sometimes desirable to combine the features of these circuits to obtain a rejector which gives a very large attenuation at the rejection frequency, but does not appreciably affect the passband of the coupling into which it is inserted. The form of this

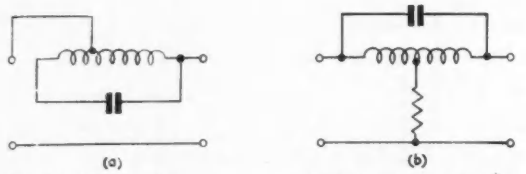

Fig. 1(a). Tapped rejector (b). Symmetrical bridged-T

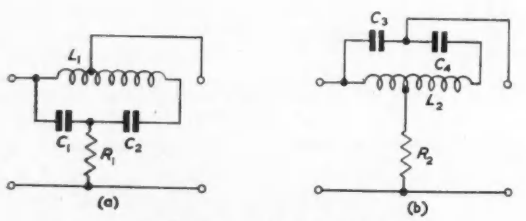

Fig. 2. Tapped bridged-T rejectors

circuit is shown in Fig. 2(a) and an alternative in Fig. 2(b) with the bridging resistor tapped into the inductive arm. The conditions for infinite attenuation will be established in both cases and approximations given which yield simple formulæ for practical use.

The method employed is to change the network into the form of Fig. 3 and, ignoring the impedances Z_1, Z_2, apply the stated conditions to the parallel arms. Fig. 4 is the circuit of Fig. 2(a) with the coil given an equivalent circuit and the inherent resistances added. Then the impedance of the upper arm is:

$$R_A + jX_A = R_3 + j\omega(L_3 + M) \quad \ldots\ldots\ (1)$$

The *T* to π transformation is applied to the lower arm and yields:

$$R_B + jX_B = R_4 - \frac{1}{\omega^2 C_1 C_2 R_1} + \frac{L_4 + M}{C_1 R_1} + j\,[\omega(L_4 + M) - 1/\omega C_2 - 1/\omega C_1] \quad \ldots\ldots\ (2)$$

Applying the conditions stated in Fig. 3, equating real and imaginary parts:

$$R_1 = \frac{1}{R_3 + R_4}\left(\frac{1}{\omega^2 C_1 C_2} - \frac{L_4 + M}{C_1}\right) \quad \ldots\ (3)$$

$$\omega^2(L_3 + L_4 + 2M) = 1/C_1 + 1/C_2 + R_4/C_1 R_1 \quad \ldots\ (4)$$

$R_3 + R_4$ may be replaced by $\omega L_1/Q$, where Q is the Q-factor of the whole coil and, since $L_3 + L_4 + 2M = L_1$:

$$R_1 = Q/\omega L_1\left(\frac{1}{\omega^2 C_1 C_2} - \frac{L_4 + M}{C_1}\right) \quad \ldots\ldots\ (5)$$

$$\omega^2 L_1 = 1/C_1 + 1/C_2 + R_4/C_1 R_1 \quad \ldots\ldots\ (6)$$

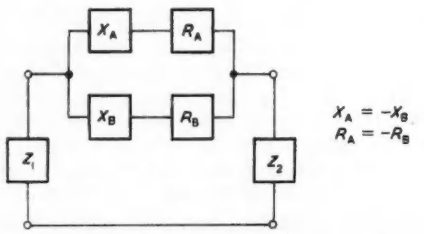

Fig. 3. Equivalent circuit and infinite attenuation conditions

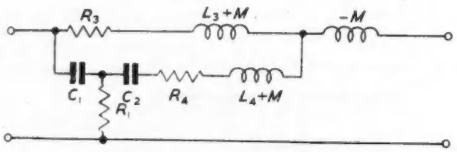

Fig. 4. Equivalent circuit of Fig. 2(a)

These equations give the required conditions and may be simplified by certain approximations. In practice R_4 can be small compared to R_1, so that the last term in equation (6) may be neglected. If close coupling is assumed between the two coil sections and if n_1 is the turns ratio of L_4 to L_3:

$$L_4 + M = \frac{n_1 L_1}{1 + n_1} \quad \ldots\ldots\ (7)$$

Let the total series tuning capacitance be C_s where

$$1/C_s = 1/C_1 + 1/C_2 \quad \ldots\ldots\ (8)$$

* *Ferguson Radio Corporation Limited.*

Equation (6) reduces to:

$$\omega^2 L_1 C_s = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Then equation (5) may be written:

$$R_1 = Q/\omega C_1 = \left(\frac{1}{1+n_1} - C_s/C_1\right) \ldots (10)$$

Thus for given values of Q, L_1, n_1, C_1, equations (8), (9) and (10) enable R_1, C_s and C_2 to be calculated. The maximum permissible value of R_1 may be found by differentiating equation (10).

$$dR_1/dC_1 = Q/\omega C_1^2\left(2C_s/C_1 - \frac{1}{1+n_1}\right) = 0$$

$$C_1 = 2C_s(1+n_1) \quad \ldots\ldots\ldots\ldots\ldots (11)$$

giving:

$$R_1 = \frac{Q}{4\omega C_s(1+n_1)^2} \quad \ldots\ldots\ldots\ldots\ldots (12)$$

Putting $n_1 = 0$ the symmetrical case is obtained

$$R_1 = Q/4\omega C_s \quad \ldots\ldots\ldots\ldots\ldots (13)$$

$$C_1 = 2C_s \quad \ldots\ldots\ldots\ldots\ldots (14)$$

The alternative circuit of Fig. 2(b) is developed in Fig. 5

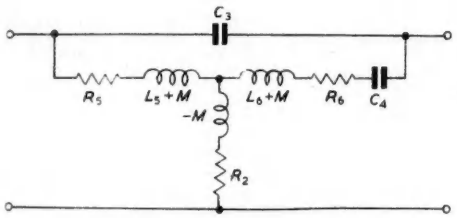

Fig. 5. Equivalent circuit of Fig. 2(b)

and may be treated in a similar manner. The top arm has the impedance:

$$R_A + jX_A = -j/\omega C_3 \quad \ldots\ldots\ldots\ldots\ldots (15)$$

Applying the T to π transformation to the lower arm:

$$R_B + jX_B = R_5 + j\omega(L_5+M) + R_6 + j\omega(L_6+M) - j/\omega C_4 + \frac{[R_5 + j\omega(L_5+M)]\,[R_6 + j\omega(L_6+M) - j/\omega C_4]}{R_2 - j\omega M} \ldots (16)$$

Using the conditions in Fig. (3), equating real and imaginary parts:

$$R_2(R_5+R_6) = \omega M[1/\omega C_3 + 1/\omega C_4 - \omega(L_5+L_6+2M)] + \omega^2(L_5+M)(L_6+M) - 1/C_4\,(L_5+M) - R_5R_6 \quad \ldots\ldots (17)$$

$$R_2[1/\omega C_3 + 1/\omega C_4 - \omega(L_5+L_6+2M)] + \omega M(R_5+R_6) = R_5[\omega(L_6+M) - 1/\omega C_4] + \omega R_6(L_5+M) \quad \ldots (18)$$

It is appropriate to introduce approximations at this stage to reduce the complexity of the equations. Assuming, as before, that the coil has closely coupled sections with a turns ratio n_2 between L_6 and L_5, that Q is the Q-factor of the whole coil and effective resistance is proportional to turns:

$$M = \frac{n_2 L_2}{(1+n_2)} \quad \ldots\ldots\ldots\ldots\ldots (19)$$

$$L_5 + M = \frac{L_2}{1+n_2} \quad \ldots\ldots\ldots\ldots\ldots (20)$$

$$L_6 + M = \frac{n_2 L_2}{1+n_2} \quad \ldots\ldots\ldots\ldots\ldots (21)$$

$$L_5 + L_6 + 2M = L_2 \quad \ldots\ldots\ldots\ldots\ldots (22)$$

$$R_5 + R_6 = \omega L_2/Q \quad \ldots\ldots\ldots\ldots\ldots (23)$$

$$R_5 = \frac{\omega L_2}{Q(1+n_2)} \quad \ldots\ldots\ldots\ldots\ldots (24)$$

$$R_6 = \frac{\omega L_2 n_2}{Q(1+n_2)} \quad \ldots\ldots\ldots\ldots\ldots (25)$$

Equation (17) becomes:

$$R_2 = \frac{1}{(1+n_2)^2}\left[Qn_2/\omega C_3 + Qn_2/\omega C_4 - \frac{\omega L_2 n_2}{Q} - \frac{Q(1+n_2)}{\omega C_4}\right] \quad (26)$$

Equation (18) becomes:

$$1/\omega C_3 + 1/\omega C_4 - \omega L_2 = \frac{\omega L_2}{QR_2(1+n_2)^2}\left(\omega L_2 n_2 - \frac{1+n_2}{\omega C_3}\right) \quad (27)$$

Substitution from (27) in (26) for R_2 gives:

$$Qn_2/C_3^2 + Qn_2/C_3C_4 - Q/C_3C_4 - Q/C_4^2 = \omega^2(Qn_2L_2/C_3 + L_2n_2/QC_3 - QL_2/C_4 - L_2/QC_4) \ldots (28)$$

Neglecting L_2n_2/QC_3 compared to Qn_2L_2/C_3 and L_2/QC_4 compared to QL_2/C_4

$$\omega^2 L_2 = \frac{C_3 + C_4}{C_3C_4} \quad \ldots\ldots\ldots\ldots\ldots (29)$$

Let the total tuning capacitance be C_T where:

$$1/C_T = 1/C_3 + 1/C_4 \quad \ldots\ldots\ldots\ldots\ldots (30)$$

Then:

$$\omega^2 L_2 C_T = 1 \quad \ldots\ldots\ldots\ldots\ldots (31)$$

From (26) putting $\omega L_2 = 1/\omega C_T$:

$$R_2 = \frac{Q}{(1+n_2)^2}(n_2/\omega C_3 - 1/\omega C_4 - n_2/\omega C_T Q^2) \ldots (32)$$

Neglecting $n_2/\omega C_T Q^2$ compared to $1/\omega C_4$ and using equation (30):

$$R_2 = \frac{Q}{\omega C_3(1+n_2)^2}(1 + n_2 - C_3/C_T) \quad \ldots\ldots (33)$$

Equations (30), (31) and (33) enable C_4, L_2 and R_2 to be found for given values of Q, C_T, C_3 and n_2. The maximum permissible value of R_2 is found by differentiation of equation (33):

$$dR_2/dn_2 = \frac{Q}{\omega C_3(1+n_2)^2} - \frac{2Q}{\omega C_3(1+n_2)^3}(1+n_2-C_3/C_T) = 0 \quad \ldots (33)$$

Then:

$$n_2 = 2\,C_3/C_T - 1 \quad \ldots\ldots\ldots\ldots\ldots (34)$$

$$R_2 = \frac{Q}{\omega C_T(1+n_2)^2} \quad \ldots\ldots\ldots\ldots\ldots (35)$$

The symmetrical case is given when $n_2 = 1$.

Then:

$$R_2 = Q/4\omega C_T \quad \ldots\ldots\ldots\ldots\ldots (36)$$

$$C_4 = \infty \text{ (short-circuit)} \quad \ldots\ldots\ldots\ldots\ldots (37)$$

Adjustment of these circuits may be made by varying one of the capacitors or by means of an iron dust core in the coil. In the latter case the coil tap may be moved slightly or the bridge resistor adjusted to allow for the unbalance introduced by the presence of the core.

A Simple Quartz Crystal Oscillator driven by a Junction Transistor

By H. G. Bassett*, B.Sc.(Eng.), A.M.I.E.E.

The oscillator uses a junction transistor with grounded-base, together with a quartz crystal operating in its series mode. Using present-day transistors the circuit can operate at frequencies up to about 300kc/s and power outputs up to 10mW or so. An experimental oscillator operates from a 6V supply and delivers 7mW at 245·9kc/s.

SIMPLE quartz crystal oscillators employing thermionic valves make use of the parallel resonance of the crystal because of the high input impedance of the thermionic pentode when used with grounded cathode. In the design of simple transistor oscillators, however, the low impedance of the emitter circuit of the transistor makes the use of the series resonance of the quartz crystal much more attractive. The oscillator described accordingly uses a series resonant quartz crystal and a grounded-base junction transistor; the simplicity, low power consumption and good frequency stability of the oscillator make it attractive where the power output is not required to be more than a few milliwatts and where the frequency is not higher than about 300kc/s (for currently available transistors). High-frequency junction transistors such as the thin-base unit described by Mueller & Pankove[1] and the pnip unit[2] will enable higher operating frequencies to be attained.

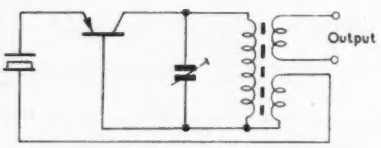

Fig. 1. Basic circuit of oscillator

Description of Circuit

Fig. 1 shows the basic circuit arrangement; d.c. supply circuits are omitted for simplicity. The transistor is used with grounded base because it can then operate usefully at frequencies in the carrier telephony range; the positive feedback is provided from the collector to the emitter via a tuned transformer and the quartz crystal which is connected in series with the emitter circuit. At the series resonance the impedance of the quartz crystal is low and the tuned transformer is so designed that at this frequency there is an overall current gain round the feedback loop when the third (output) winding of the transformer is closed with its designed load impedance. The d.c. supply circuit is arranged so that the transistor is biased to the centre of its linear operating regime; it stabilizes the emitter current of the transistor in the manner described by Shea[3]. Fig. 2 shows the complete circuit diagram. Amplitude limiting occurs under operating conditions by collector-current cut-off at one end of the linear regime and by collector voltage "bottoming" at the other end; in the simple oscillator described these limiting processes control the amplitude of oscillation and make it almost proportional to the supply voltage. Inevitably harmonic components are introduced into the output signal, but by suitable design of the output transformer the harmonics are kept to an acceptably low level. A feature of the circuit is that the attenuation of harmonic frequencies around the feedback loop is large (more than 50dB in the experimental oscillator). The discrimination against harmonic frequencies assists frequency stability.

Choice of Operating Conditions

The choice of operating conditions for the transistor is not as straightforward as the choice of operating conditions

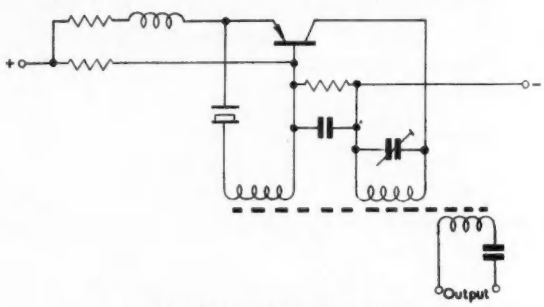

Fig. 2. The complete oscillator circuit

in a thermionic valve oscillator. Thus, if the transistor is operated with an amplitude of voltage V and an amplitude of current I in its collector circuit, the power in the collector circuit, P_c, is $VI/2$. If the current gain is α and the input resistance (crystal + emitter circuit) is R_e, the power, P_e, fed back to the input circuit must be $(I/\alpha)^2 R_e/2$.

The external output power, P_o, of the oscillator is then $VI/2 - (1/\alpha)^2 R_e/2$ if we neglect transformer losses. If we assume that the transformer ratio is suitably changed, the change of output power with change of V and I is given by:

$$dP_o = \partial P_o/\partial V\ dV + \partial P_o/\partial I\ dI$$
$$= I/2\ dV + (V/2 - I/\alpha^2 R_e)\ dI$$

and maximum external power output is obtained from the oscillator when:

(a) V is as large as possible;

(b) $V/2 = I/\alpha^2 R_e$.

It follows from the second condition that $I = V\alpha^2/2R_e$, and hence $P_{o(max)} = V^2\alpha^2/8R_e$. There is therefore an upper limit to the output power obtainable from the oscillator, independent of any limitation upon output imposed by maximum collector dissipation.

Using present-day transistors, $P_{o(max)}$ is often of the same

* *Post Office Engineering Department.*

order as the maximum collector dissipation. It follows from condition (a) that V should be as large as possible; even if maximum power output is not desired, the efficiency of the oscillator increases as V is raised.

Performance of an Experimental Oscillator

An experimental oscillator has been constructed which delivers 7mW at 245·9kc/s when powered with a 6V dry battery. The current consumption is 6·2mA and the transistor operates with $V = 5V$, $I = 6mA$. The quartz crystal is a CT-cut unit, mounted in an evacuated envelope and having a series resonant impedance of about 200Ω; the value of R_e is then about 250Ω. The oscillator is designed to operate at maximum power output in accordance with the foregoing analysis; it has at the time of writing completed over 2 000 hours of operation. The circuit is very tolerant of variations in transistor parameters; changes in collector impedance and collector cut-off current are unimportant and the oscillator operates satisfactorily with a wide range of transistors from various manufacturers. The oscillator functions satisfactorily up to at least 50°C; the change of output level with temperature is 0·02dB/°C and the change of frequency with temperature is almost entirely attributable to the quartz crystal. The frequency stability against 10 per cent change of supply voltage is 3×10^{-7}.

Acknowledgments

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REFERENCES

1. Mueller, C. W., Pankove, J. I. A PNP Triode Alloy Junction Transistor for Radio-frequency Amplification. *Proc. Inst. Radio Engrs. 42*, 386 (1954).
2. Early, J. M. PNIP and NPIN Junction Transistor Triodes. *Bell Syst. Tech. J. 33*, 517 (1954).
3. Shea, R. F. Transistor Operation ; Stabilisation of Operating Points. *Proc. Inst. Radio Engrs. 40*, 1435 (1952).

Colour Television Equipment

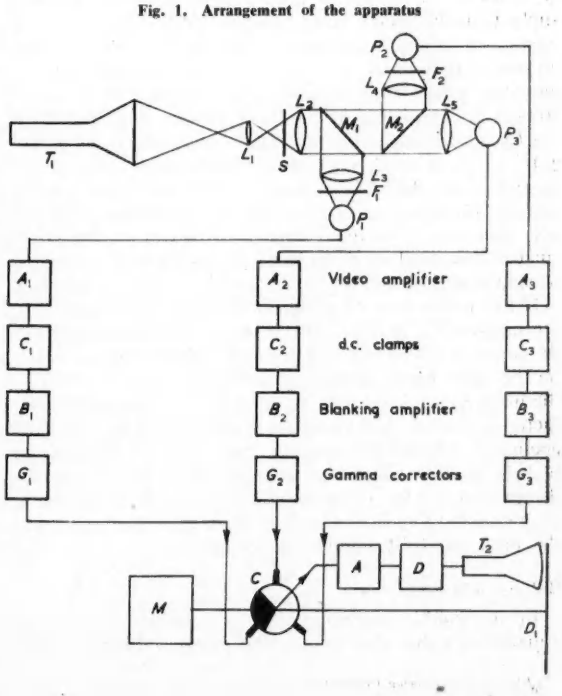
COLOUR television equipment has been constructed by the staff of the Electrical Engineering Department of the Bradford Technical College under the direction of the Head of the Department, Dr. G. N. Patchett in order to show the principles of colour transmission and reception to students. The equipment consists of a flying spot colour slide camera and a receiver using a rotating colour disc.

The flying spot colour slide camera uses a special flying spot scanning tube T_1 (see Fig. 1) which operates with a final anode voltage of 25kV. The tube has a green fluorescent screen with an extremely short afterglow, an essential property of any flying spot scanning tube. The raster on this tube is focused on to the colour slide S by a 5cm, $f1{\cdot}5$ lens L_1. The light leaving the colour slide is made into an approximately parallel beam by lens L_2. The light is now split into the three primary colours, red, green and blue. This is achieved by dichroic mirrors M_1 and M_2. Mirror M_1 is made so as to pass red and green light but reflect blue light, this being focused, by lens L_3, on to the cathode of the photo-multiplier cell P_1, which produces a signal corresponding to the blue image of the colour slide. A correcting filter F_1 is placed in front of the cell to correct the colour response. The red light passing through M_1 is now reflected from the mirror M_2 through lens L_4 and filter F_2 on to the cathode of the photo-multiplier P_2 which produces a signal corresponding to the red image. The green light passes through mirrors M_1 and M_2 and is focused by the lens L_5 on to the photo-multiplier cell P_3 which produces a signal corresponding to the green image.

The three signals are now passed through video amplifiers A_1, A_2 and A_3 with adjustable gains so as to adjust the contrast of each colour image. It is now necessary to set the black level of the signals which is done by the three d.c. clamping circuits C_1, C_2 and C_3. During both line and frame flyback periods the beam on the flying spot tube is suppressed and clamping is applied during the line flyback periods. Adjustment of the clamping voltage controls the brightness (or d.c. level) of each colour on the receiving tube. A blanking signal is now applied to cut off any signal during the line and frame flyback by the blanking amplifiers B_1, B_2 and B_3. After this gamma correction is applied (in G_1, G_2 and G_3) to compensate for the non-linearity of the receiving cathode-ray tube. The three signals are now fed to a commutator C driven at 1 000 rev/min by a synchronous motor M which is constructed so as to feed the three signals, in order, to the receiving tube T_2, through the video amplifier (A) and d.c. restorer (D). Attached to the same shaft is a disk D_1 which rotates in front of the receiving tube. The disk is divided into three sectors of 120°. Over the sectors are placed red, green and blue filters so arranged that when the green filter is in front of the cathode-ray tube the green photo-multiplier is connected through the commutator to the grid of the tube, and so on. In this way successive red, green and blue images are seen by the observer, which, due to the persistence of vision, results in a colour picture. The system runs at 405 lines with 50 frames/second. Since the time between similar colour frames is 3/50 second flicker is rather bad, but, as the equipment was designed to show the principle only it is of little importance. It could, of course, be improved by raising the frame frequency but this has been kept at 50 frames/second so that a common pulse generator could be used for both the black and white camera and the colour equipment.

The colour rendering of the equipment is very satisfactory when carefully adjusted but, like all colour systems, it is very critical to the correct relationship between the three primary colours. The definition corresponds to about 2Mc/s. Interesting demonstrations can be given of the effect of reducing the bandwidth of the various channels. Considerable reduction can be made in the bandwidth of the blue channel without altering the picture detail. A small reduction in the bandwidth of the red, and particularly of the green channel soon shows up in the definition of the resulting picture.

Fig. 1. Arrangement of the apparatus



A New Circuit for Balancing the Characteristics of Pairs of Valves

By R. E. Aitchison*

Various methods for adjusting the balance of a pair of triodes are considered. A new method is suggested which is based upon the adjustment of the cathode temperature so that the static anode currents are made equal. Measurements indicate that under these conditions the mutual conductances are then nearly equal, and the behaviour with respect to overall heater voltage changes is also improved.

IN many applications, and particularly in the case of d.c. amplifiers, it is desirable to have a pair of identical valves. For example, in push-pull power output circuits this is necessary to obtain an exactly balanced push-pull output. In the case of d.c. amplifiers the pair of valves are arranged so that the effect of changes in supply voltages on the characteristic of one valve are compensated by changes in a similar, preferably identical, valve. Similarly, compensation is obtained for any change in the valve characteristics with time. Unfortunately, it is very difficult to obtain identical valves, particularly in the case of valves with an oxide cathode; and some means must be adopted in the associated circuits of adjusting for differences between pairs of valves.

Triode Parameters

The small signal parameters of a valve (for the sake of simplicity a triode is chosen, but similar arguments apply to pentodes at fixed screen voltage) which are of interest are the amplification factor (μ), the mutual conductance (g_m), and the static anode current (I_a), all measured under fixed conditions, i.e., heater voltage, anode voltage, and grid bias. (Note the dynamic anode resistance is μ/g_m and is hence implied from a knowledge of μ and g_m). The static anode current is important, as it determines the static d.c. balance of balanced circuits, obviously of extreme importance in the case of d.c. amplifiers, although it is desirable from many points of view that the anode currents be equal in push-pull a.c. circuits—i.e., reduction of ripple, and of d.c. saturation of the output transformer.

If the parameters of a series of valves of the one type are measured it is found that μ shows small deviations of the order of a few per cent from the mean. The g_m and I_a, on the other hand, deviate by well over ten per cent from the mean value. This is to be expected, as the amplification factor is, under ideal conditions, determined by the valve geometry, which with normal construction methods can be held to close tolerances, whereas the g_m and I_a are also determined by the cathode emission, which is known to vary considerably in the case of oxide cathodes, even with the most carefully controlled production.

Balance Circuits

In any double triode circuit it is possible to adjust for equality of either the static anode currents, the stage gain, or the effect of heater changes, but not for all three simultaneously. Normally, adjustments are made for equality of the static anode currents, or zero adjustment. Methods of doing this are shown in Fig. 1. For example, the anode supply may be taken through a potentiometer as in 1(a), and this adjusted for static balance. Alternatively, the bias can be changed as in 1(b) so as to give static balance. Finally, the valve may be shunted with a resistor as in 1(c). Unfortunately, if other adjustments are

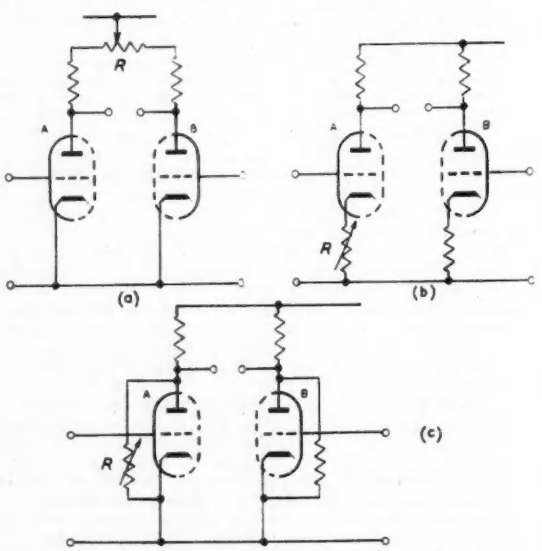


Fig. 1. Three basic methods used to balance the static properties of a pair of triodes

introduced so as to equalize also the stage gain and the effect of heater changes, the various adjustments are not independent, and in a multi-stage amplifier the use of three interacting controls on each stage would be impracticable.

More elaborate circuits have been devised to balance the anode current and the gain simultaneously[1]. However, these methods are based on the use of a large cathode resistance common to both valves, this serving to nearly balance the dynamic properties, and one of the methods of Fig. 1 is then used to balance the static currents. An

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TABLE 1

Differences Between Twin Triodes Before and After Balancing by Heater Compensation

VALVE NUMBER	HEATER VOLTAGE DIFFERENCE (V)	GRID BIAS (V)	I_{a1} (mA)	I_{a2} (mA)	g_{m1} (μA/V)	g_{m2} (μA/V)	ΔI_a (mA)	Δg_m (μA/V)
1	0·0	2·2 2·0 1·8	1·00 1·37 1·82	0·815 1·18 1·545	2 160	1 825	0·19	335
	0·67	2·2 2·0 1·8	0·905 1·275 1·68	0·91 1·275 1·68	1 945	1 925	0·0	20
2	0·0	2·2 2·0 1·8	1·04 1·41 1·875	0·97 1·31 1·745	2 155	1 940	0·10	215
	0·23	2·2 2·0 1·8	0·98 1·39 1·83	0·99 1·39 1·82	2 110	2 050	0·0	60
3	0·0	2·2 2·0 1·8	1·11 1·49 1·965	0·925 1·27 1·68	2 160	1 890	0·22	270
	0·57	2·2 2·0 1·8	1·015 1·39 1·86	1·015 1·39 1·87	2 110	2 140	0·0	30
4	0·0	2·2 2·0 1·8	1·03 1·41 1·84	0·99 1·365 1·785	2 075	1 990	0·045	85
	0·13	2·2 2·0 1·8	1·03 1·41 1·825	1·04 1·41 1·83	1 990	1 975	0·0	15
5	0·0	2·2 2·0 1·8	0·89 1·285 1·68	1·04 1·44 1·84	1 975	2 115	0·155	140
	0·38	2·2 2·0 1·8	0·96 1·35 1·78	0·97 1·35 1·775	2 045	2 010	0·0	35
6	0·0	2·2 2·0 1·8	2·975 1·36 1·79	0·98 1·36 1·78	2 040	2 000	0·0	40
7	0·0	2·2 2·0 1·8	0·86 1·20 1·60	0·83 1·15 1·52	1 860	1 725	0·05	135
	0·18	2·2 2·0 1·8	0·835 1·18 1·6	0·83 1·18 1·52	1 815	1 850	0·0	35
8	0·0	2·2 2·0 1·8	1·10 1·49 1·93	1·11 1·47 1·89	2 075	1 950	0·02	125
	0·06	2·2 2·0 1·8	1·11 1·50 1·95	1·12 1·50 1·93	2 050	2 025	0·0	25
9	0·0	2·2 2·0 1·8	1·33 1·76 2·30	0·925 1·28 1·72	1 550	1 985	0·48	565
	0·73	2·2 2·0 1·8	1·11 1·55 2·01	1·12 1·55 2·03	2 310	2 300	0·0	10

example of this type of balance circuit is given in Fig. 2. However, this method is applicable only when using parallel balanced triodes with a large value of the common cathode resistor R, and hence is not applicable in many cases.

New Balance Circuit

As the differences between triodes of the same type are mainly caused by differences in the emission from the cathode, it should be possible to balance valves by making the cathode emission the same. A new circuit[4] based upon this fact is shown in Fig. 3. A potentiometer of a few ohms resistance is connected as shown so as to introduce a small difference ΔV_h in the heater voltages of the valves 1 and 2. The simplest procedure is to adjust R so that the static anode currents of the valves are equal. If necessary, the overall heater supply can be increased slightly, but in many applications, for example in the case of d.c. amplifiers, it is desirable to run the heaters at a reduced voltage and the overall drop in R is not important.

It was found experimentally that the maximum difference in voltage between the two triodes amounted to 10 per cent of the normal for a batch of 50 twin triodes type 12AX7,

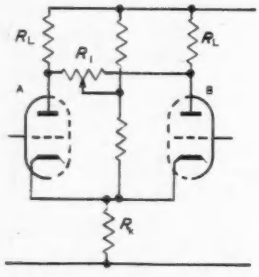


Fig. 2. A method for balancing both the static and dynamic properties of a pair of triodes

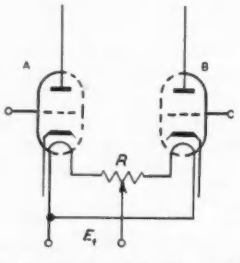


Fig. 3. New circuit for the overall balance of a pair of triodes

and that of these approximately half could be balanced with heater voltage differences of only 5 per cent.

As the potentiometer R is set so as to equalize the static anode currents, the valves will be perfectly balanced if the mutual conductances are equal and they respond equally to the effect of heater supply changes.

These two points were checked by measurements on a number of valves type 12AX7. Measurements on the mutual conductance are given in Table 1. The twin triode type 12AX7 was first tested at fixed heater voltage, then the heater voltages were adjusted for static balance at the recommended test conditions (anode voltage 250V, grid bias $-2{\cdot}0$V). The dynamic balance was next measured by measuring the mutual conductance, and also the anode current at a grid bias of $-2{\cdot}2$V and $-1{\cdot}8$V. It is obvious that for all the valves tested the mutual conductances after balancing for I_a are almost identical. This would probably hold only for triodes of near-identical geometry, where the unbalance is caused solely by the differences in work function of the cathode. Once the emissions are made equal by adjustment of the cathode temperatures, the valves should then be identical apart from a slight difference in the escape voltage of the electrons from the cathodes. It is possible that the differences in temperature will introduce other side effects such as differences in life of the two triodes, different rates of poisoning, etc. However, balance adjustments are normally a routine adjustment in the case of d.c. amplifiers. The twin triode No. 1 of Table 1 was tested after 100 hours and the balance adjustment was found to have changed by 0·07V, the new value of ΔV_h being 0·60V. It should be noted that out of the nine valves tested, one valve (No. 6) showed anode currents and mutual conductances to be nearly balanced without any further compensation.

Of major importance in d.c. amplifier design is the effect of heater supply variations, and several circuits are used to balance a pair of triodes for equality in changes due to heater supply changes[2, 3]. Although the new circuit makes the cathode temperatures different, all other properties are nearly balanced, and to a first order it would be expected that the stability to heater supply variations would be also balanced. Measurements in Table 2 give the effect of a change of + and − 5 per cent on the overall heater supply. As is clear from these measurements, the

TABLE 2

VALVE NUMBER	HEATER SUPPLY	HEATERS NOT COMPENSATED		HEATERS COMPENSATED	
		I_{a1} (mA)	I_{a2} (mA)	I_{a1} (mA)	I_{a2} (mA)
4	Normal	1·41	1·365	1·40	1·40
	+5%	1·50	1·46	1·47	1·47
	−5%	1·37	1·32	1·33	1·33
5	Normal	1·285	1·44	1·325	1·325
	+5%	1·35	1·49	1·39	1·395
	−5%	1·21	1·37	1·27	1·275
6	Normal	1·36	1·36	—	—
	+5%	1·425	1·42	—	—
	−5%	1·275	1·28	—	—
7	Normal	1·20	1·15	1·18	1·18
	+5%	1·28	1·22	1·6	1·575
	−5%	1·16	1·11	0·835	0·83
8	Normal	1·48	1·47	1·50	1·50
	+5%	1·58	1·56	1·55	1·55
	−5%	1·44	1·42	1·43	1·425
9	Normal	1·76	1·28	1·55	1·55
	−5%	1·85	1·35	1·66	1·65
	−5%	1·67	1·22	1·50	1·49

compensation is good but not perfect. However, this result is typical of all heater compensation circuits, which rarely give an improvement of better than 20 : 1 (Verhagen[1]).

Conclusions

It is concluded that the new balance circuit of Fig. 3 is capable of giving, simultaneously, an accurate balance of the static anode currents and mutual conductances of pairs of triodes. As the amplification factors are normally also balanced, this gives a pair of triodes, without selection, identical to within a few per cent. At the same time the balance with respect to overall heater supply changes is improved sufficiently to render heater compensation circuits unnecessary.

REFERENCES

1. VERHAGEN, C. N. A Survey of the Limits of A.C. Amplification. *Proc. Inst. Radio Engrs. 41*. 615 (1953).
2. MILLER, S. E. Sensitive D.C. Amplifier with A.C. Operation. *Electronics 14*, 27 (Nov. 1941).
3. ARTZT, M. Survey of D.C. Amplifiers. *Electronics 18*, 112 (Aug. 1945).
4. AITCHISON, R. E. A New Circuit for Balancing Pairs of Valves. *Nature 174*, 704 (1954).

Notes from North America

Highlights from I.R.E. Convention

New medical, dental and industrial uses of ultrasonics were announced at the national convention of the Institute of Radio Engineers held recently in New York.

John M. Reid and John J. Wild, M.D., reported that ultrasonic energy has been successfully used at St. Barnabas Hospital, Minneapolis, to diagnose lumps in the human breast before operation. When the narrow sound beam encounters human tissue, a pattern of echoes is returned and displayed on a television picture tube.

Irregularities such as cancer, non-malignant solid tumors and liquid-filled cysts can be recognized from their characteristic pictures. Several echo photographs of typical lesions were shown for the first time at a session of ultrasonic specialists at the Belmont Plaza Hotel.

In another paper at the same session, Douglas H. Howry, M.D., University of Colorado Medical Center, disclosed a technique which permits use of ultrasonic echo equipment for studying vital organs deep within the human body. Ultrasonics may supplement X-rays as a diagnostic aid. Although X-rays are invaluable in studying the body's bony structure, they cannot always give an adequate picture of soft tissue.

The use of ultrasonics in clinical dentistry was described by Alvin E. Strock, Peter Bent Brigham Hospital in Boston. Much of the discomfort associated with visits to the dentist may be alleviated by an ultrasonic dental drill developed by the Cavitron Corp. of Long Island City and described in a companion paper by Lewis Balamuth. An ultrasonic drill is used to abrade or wear away the decayed parts of the tooth. It does its work rapidly and without force being exerted by the dentist. The patient is spared the uncomfortable sensations of heat and pressure caused by a mechanical drill.

Industrial applications of ultrasonics were also described including studying river currents to determine the best place to build a hydro-electric station, removing the chaff from textile fabrics and determining the mechanical strength of manufactured products non-destructively.

A single colour television camera tube which does the work of the three tubes used in present day cameras was reported under development by RCA Laboratories. The new tube is capable of responding to all three primary colours at once instead of just to a single colour. The development was announced in a paper presented by P. K. Weimer, S. Gray, H. Borkan, S. A. Ochs, and H. C. Thompson, of RCA.

A system by which radar information may be transmitted by ordinary telephone lines from a distant radar station to a radar viewing screen was disclosed by C. W. Doerr and J. L. McLucas of Haller, Raymond and Brown, Inc. At the present time coaxial cables or expensive microwave relay systems are required for this purpose at airports and for radar networks.

Thirty tons of printed matter on paper 8in wide in an 8-hour day or a printing speed of 5 000 characters a second; this is the possible output of a new and basic recording technique developed by the Burroughs Corporation.

H. Epstein and F. Innes in a paper titled "Electrographic Recording", revealed the development by which a mark may be put on a paper in a duration as small as one microsecond and that printed characters, formed by combination of such marks, could be recorded at rates exceeding 5 000 characters per second. This system will be particularly useful in electronic computer systems, teletypewriter and telemetering services, facsimile, etc., where the output of the machine is to be displayed as a printed message.

The development of a new type of high-gain transmitting antenna for television broadcasting in the u.h.f. band was described by O. M. Woodward of RCA, and James Gibson of Sweden. In another session, a new type of television transmitting antenna which eventually should work to the advantage of the set-owner (especially in colour television) as well as to the broadcaster and manufacturer, was outlined by R. W. Masters and C. J. Rauch of Ohio State University.

The technical aspects of television in Europe, with its many different engineering standards creating problems in channel allocation, set manufacture, and international programme exchange, were summarized by Hubert A. S. Gibas of Switzerland.

The possibility of using man-made space satellites as a means of relaying television across the ocean was disclosed by Dr. John R. Pierce, director of electronics research of Bell Laboratories.

Good reception would be electronically feasible by using a 100ft satellite in an orbit 22 000 miles above the earth to reflect television signals from one continent to another. This would require an antenna 250ft in diameter at the sending and receiving stations on earth and a transmitter power of only 50kW. At such time as it becomes possible to construct such a satellite, the chief problem would be keeping the satellite's reflecting surface steadily aimed in the proper direction.

Among other speakers at the symposium was Prof. S. F. Singer, physics department of the University of Maryland, who reported that the technical problems connected with launching, control and instrumentation of a very small man-made satellite called the MOUSE (Minimum Orbital Unmanned Satellite of the Earth) are well within the range of present techniques. Among the many scientific instruments which would be installed in the MOUSE would be one which measures the sunlight reflected by the earth. This would give a measure of the total world cloud coverage which, in turn, could be used to forecast long-range climatic changes.

Edward F. Feldman, speaking at a session on instrumentation, described an electronic test instrument which automatically analyses sounds and noises and displays their frequency components on a cathode-ray tube. The instrument is useful in such projects as silencing business machines, measuring high fidelity equipment, and finding faults in precision ball bearings.

The Physical Society's 39th Exhibition

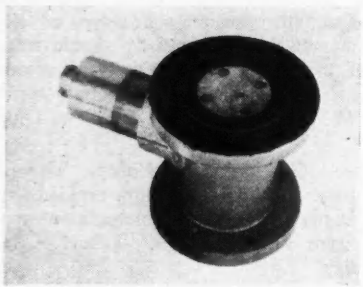
A description, compiled from information supplied by the manufacturers, of selected exhibits at the Physical Society's Exhibition held at the New Hall of the Royal Horticultural Society, London, from 25th to 28th April.

Boulton Paul

Load Cells

(Illustrated below)

A NEW range of load cells is being developed, using differential transducers as the means of measuring the displacement under load. This feature almost completely eliminates errors due to non-axial loading and avoids difficulties of creep associated with strain gauges. These cells will be of interest to manufacturers and users of rolling mills and allied machinery. The accurate measurement of loading can be used as the safety device, ensuring that the machine is never overloaded.



Displacement Transducer

THE EP 303 is an entirely new displacement transducer, capable of measuring displacements of the order of 100 micro-inches. It is robustly constructed and is sufficiently small to enable it to be fitted to apparatus where other methods have proved impossible. It can be fitted to a capsule or diaphragm, so making a very sensitive pressure measuring device. It has been designed with a view to long life and should give many years of service without maintenance.

Boulton Paul Aircraft Ltd.,
Pendeford Lane,
Wolverhampton.

B.P.L.

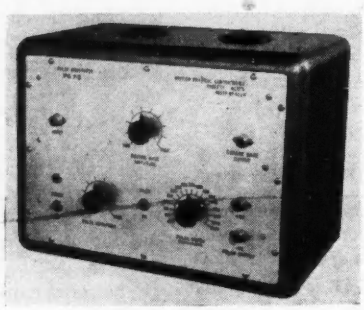
Pulse-height Valve-voltmeter

THIS instrument, Model PV 812 will read up to 100V with an accuracy of ±2 per cent and is designed to measure the height of periodically recurring pulses, being independent of pulse width and repetition rate.

Pulse Generator

(Illustrated above right)

THE pulse and square wave generator, Model PG712, has been developed as a piece of ancillary equipment to the audio-frequency signal generator which has now an extended frequency range to cover from 10c/s up to 100kc/s. It provides a means of converting sinusoidal voltages into steep fronted pulses of short duration or alternatively into square waves. The output for pulse operation is



variable up to 15V positive or negative to earth, while the maximum output for square wave generation is 10V. Both the above items are being manufactured under licence from the N.R.D.C.

British Physical Laboratories,
Houseboat Works,
Radlett,
Hertfordshire.

B.T.H.

Microwave T.R. Devices

A RANGE of X-band t.r. and t.b. broadband cells was shown. The special developments to which attention is drawn are the form of compression window seal, the copper brazed steel method of vacuum envelope construction, and the shielded gap construction which hinders deposits of material sputtered off the primer electrode from detuning the r.f. circuit. These features, together with special processing techniques, enable an average life well in excess of 1 000 hours to be achieved.

The British Thomson-Houston Co. Ltd.,
Rugby,
Warwickshire.

Cinema-Television

Flying Spot Microscope

THIS is the first production model of the prototype shown previously and incorporates a number of new features. Basically the equipment permits any normal microscope slide to be viewed on a television type screen with the advantages of greater magnification, variable contrast control and large audience viewing facilities.

A special feature of the exhibit was a demonstration of automatic particle counting.

Miniature Multi-channel Recording Equipment

THIS new equipment has been designed to meet the demand for a miniature multi-channel recording apparatus and permits from one to twelve channels to be used simultaneously. Photographic recording of the tube traces can be carried out with either a continuous feed or drum type of camera.

Each amplifier and tube unit is only 9¼in high × 2in wide × 15in deep thus permitting the units to be closely stacked together. Associated units comprise the main amplifier and power supplies.

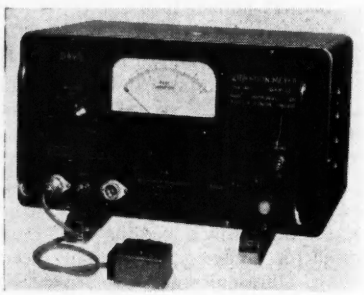
Cinema-Television Ltd.,
Worsley Bridge Road,
Lower Sydenham,
London, S.E.26.

Dawe Instruments

Vibration Meter

(Illustrated below)

THE new type 1403 vibration meter is a mains-operated instrument which uses a moving-coil pick-up in place of



the crystal pick-up of the portable type 1402 battery-operated equipment. This new pick-up provides an output voltage which is directly proportional to the vibration velocity instead of to the vibration acceleration as with the crystal pick-up. Electrical integrating and differentiating circuits are, however, incorporated in the new meter to provide a direct calibration in terms of vibration displacement and acceleration, as well as velocity.

Dawe Instruments Ltd.,
99 Uxbridge Road,
Ealing,
London, W.5.

Edison Swan

Process Controller

THIS equipment is designed to be the controlling element in automatic production plant. It is suitable for any type of machine which has controls that can be electrically or pneumatically operated.

The controller is basically a universal timer controlling up to six separate and individual functions so that they are automatically performed in the desired sequence and for the requisite time, in relation to one another. Auxiliary units are also provided so that if one or more of the functions required are to turn on or off, for example, gas/air or gas/oxygen burners, the burner supplies are turned on and off in the right sequence and with a suitable time delay to prevent explosions.

Industrial and Special Valves

THE ES1001 is a radiation cooled triode with thoriated tungsten filament and with a maximum anode dissipation of 1kW at 40Mc/s.

The ESA1002 is a forced air cooled triode with a thoriated tungsten filament and with a maximum anode dissipation of 12kW at 40Mc/s.

The 13E1 is a beam tetrode d.c. control valve for use as either a series or shunt control valve in stabilized power supplies. It is also eminently suitable for servo control motor systems. Mutual conductance approximately 40mA/V. Maximum anode dissipation 90W.

The Edison Swan Electric Co. Ltd.,
155 Charing Cross Road,
London, W.C.2.

Edwards

Quartz Crystal Vibrator Coating Plant

EDWARDS model 12QE coating plant is capable of coating batches of 16 quartz crystal vibrators in one pumping cycle and provision is made for individual frequency calibration of each crystal during the process.

A new crystal coating unit has been developed for individual crystals making use of valveless pumping in order to provide the simplest possible construction both for experimental and small batch quantities of crystals. The work-chamber is of about ½ litre capacity and can be exhausted to 10^{-4}mm of mercury by a "Speedivac" model A203 air-cooled vapour pump backed by a "Speedivac" model 1S50 rotary pump in a total time of 2½ minutes. It is sealed by one of two covers so mounted that they can be rotated horizontally as a joined pair through 180°. Each cover is fitted with a crystal holder and an evaporation source. In operation a crystal may be coated and frequency calibrated whilst the other cover is being loaded. At the finish of the coating cycle air is admitted, the covers are rotated bringing a new one into service, and the operation is repeated.

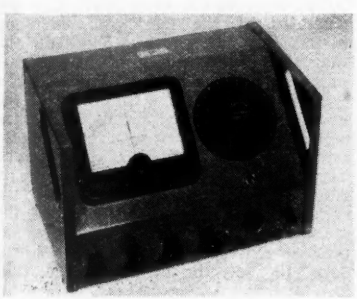
W. Edwards & Co. (London) Ltd.,
Manor Royal,
Crawley,
Sussex.

E.I.C.

A.C. Comparator

(Illustrated below)

THIS is a non-electronic alternating current bridge suitable for the measurement and grading of capacitors, chokes and resistors from mains supply.



An external power supply and an external standard are required. For capacitance measurements between 0·25 and 25μF mains frequency (50c/s) is suitable, but for lower values a higher frequency is required. Two versions of the comparator are made; an industrial model intended for factory use and a laboratory model, the latter being five times more sensitive than the former.

A capacitance decade box covering from 50pF to 1μF and suitable for use with the comparator was also shown.

The Electrical Instrument Co. (Hillingdon) Ltd.,
Boswell Square Industrial Estate,
Hillingdon,
Glasgow, S.W.2.

Elliott

Microwave Equipment

THE range of microwave equipment shown included the following:

Absolute Method of Attenuation Calibration: Equipment for 10 000 *Mc/s Band.*

Equipment is being developed which operates as a microwave bridge system, enabling attenuators to be calibrated by the provision of signals of accurately related amplitude.

Standing-Wave Indicator for 10 000*Mc/s Band.*

This is a prototype instrument of advanced mechanical and electrical design. It employs an electroformed waveguide of great accuracy, a high-precision but long-wearing travelling surface, and an improved electrical system. The whole instrument is totally enclosed, and is fitted with a dial gauge for direct reading of the probe position.

The instrument forms part of

A Complete High Precision Low-Power Test Bench for 10 000*Mc/s Band.*

This prototype test equipment enables the transmission and reflexion characteristics of most microwave components to be measured. Demonstration was made of the direct methods of measuring voltage standing wave ratio by the use of the Elliott rotary attenuator and a standing wave indicator.

A Broad-Band, High Directivity Directional Coupler for 35 000*Mc/s Band.*

This instrument, at present under development, employs a multi-slot coupling hole system and a first-grade glass vane matched load.

D.C. Magnetic Amplifier

THIS instrument is a high stability d.c. amplifier of rugged construction. By the use of second harmonic modulator input stages, stability is appreciably better than that obtained with conventional types of amplifiers, and errors are reduced to the equivalent of 10^{-12}W signal input powers. For inputs from 0 to 4mV across impedances of 20Ω to 20kΩ, the amplifier delivers 0 to 5mA into 500Ω to drive an industrial pattern recorder or indicator. Response time is one second approximately. An accuracy of ±1 per cent full scale deflexion is maintained with mains variations of ±10 per cent voltage and ±5 per cent frequency. The amplifier was demonstrated in conjunction with a magnetic amplifier relay. By means of a calibrated dial the operating point of the relay is adjustable to any point on the output characteristic of the magnetic amplifier.

Elliott Brothers (London) Ltd.,
Century Works,
Lewisham,
London, S.E.13.

Ferranti

C.R.T. Afterglow Measurement

THIS equipment is designed to determine the decay curve of luminescence of a cathode-ray tube phosphor as a function of time. It consists of two units: one unit is for short-afterglow measurement in the range from a fraction of a microsecond up to about 200msec, and the other unit for medium- and long-afterglow measurements. In the short-afterglow unit an electron beam sweeps across the phosphor under investigation in a linear trace; the light pulse passing through a narrow slit in a mask placed in front of the cathode-ray tube screen is converted by a photo-multiplier to a corresponding voltage pulse for display on a cathode-ray tube. In the second unit, when used for medium-afterglow measurements, the electron beam sweeps across the phosphor under investigation in a circular trace: the light intensity of the afterglow is measured with a photo-multiplier placed in front of a slit in the mask which rotates in front of the cathode-ray tube screen at the same speed as that of the spot, the adjustable phase difference between luminous spot and viewing slit representing the time interval of decay. If the unit is used for long-afterglow measurements, the photo-multiplier remains stationary in front of the screen and the decay of light output is timed with a watch.

Ferranti Ltd.,
Hollinwood,
Lancashire.

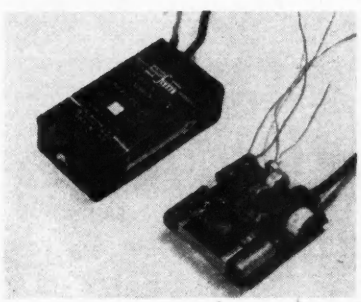
Fortiphone

Transistor Components and Applications

(Illustrated below)

A RANGE of subminiature transformers designed for use in conjunction with transistors was shown.

Transistors have proved to be a very efficient means of converting low voltages to higher voltages by using an oscillator running at 10 to 20kc/s and simple smoothing, which is all that is necessary at that frequency. Conversion efficiencies of as high as eighty per cent have been obtained, which is not possible at power levels of up to a few watts with either vibrator power supplies or rotary con-



verters. Circuits of this type and also audio frequency transistor circuits are being made up as small potted special assemblies in rectangular form as illustrated.

The unit shown contains two transformers, two transistors, two amplifiers and a number of other components and measures only ½in × 1in × 1⅞in.

Fortiphone Ltd.,
Fortiphone House,
247 Regent Street,
London, W.1.

Johnson Matthey
Wax-Protected Precision Silvered Mica Capacitors

A RANGE of wax-protected capacitors embodying silvered mica plates, covering capacitances from 5pF to 0·25μF and adjusted to a minimum capacitance tolerance of ±0·5 per cent or ±1pF (whichever is the greater). High stability, low power factor and absence of scintillation are among their characteristics. The capacitors are available with three voltage ratings—500, 350 and 200V peak—in both eyeleted and fired types.

Moulded Precision Silvered Mica Capacitors

ROBUST moulded components embodying silvered mica plates, designed to give efficient service over long periods in the temperature range −60°C to +120°C. The relationship between temperature and capacitance change is linear and cyclic. The capacitors are rated for 500V peak working, and are available in two sizes covering the capacitance range 5pF to 0·01μF.

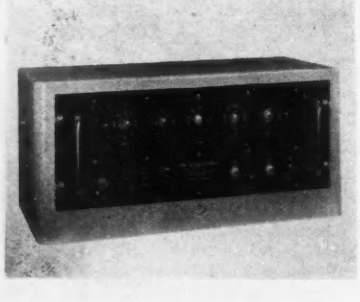
Waveguide Tubes

SEAMLESS waveguide tubes of high accuracy and excellent internal finish in copper, brass, 7½ per cent and 10 per cent copper-silver, and also in silver-lined copper. Rectangular tubes, with sharp interior angles, are available with external dimensions up to 1·25 × 0·625in. Round tubes are available with outside diameters up to 1·5in.

Johnson Matthey & Co. Ltd.,
78 Hatton Garden,
London, E.C.1.

Labgear
Time Period Counter
(Illustrated below)

THIS instrument is designed for the accurate measurement of the time interval between two events. The design



incorporates the requirements of a counter chronograph operating within the range of 10 to 10−⁴sec.

The 'time source' oscillator employs a 10kc/s quarts crystal having a frequency stability better than 0·02 per cent. The counter section consists of a single GC10D stage and four stages of GC10B Dekatron glow-transfer tubes with hard-valve couplings.

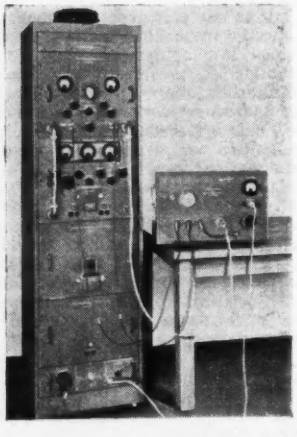
Provision is made for extension of the normal 10sec count range to 10 000sec by the addition of an external Dekatron register.

A flexible triggering arrangement, employing a pentode gate of negligible resolving time in conjunction with two gas-trigger holding tubes, permits the use of pulses derived from either a common origin or from independent sources. Alternatively, a mechanical contact sequence may be accommodated.

Labgear (Cambridge) Ltd.,
Willow Place,
Cambridge.

Marconi Instruments
E.H.F. Signal Generator (0A 1000)
(Illustrated below)

ELECTRICALLY this equipment divides into three main parts: (1) a klystron microwave oscillator which can



be preset for operation at frequencies between 33 300 and 37 500Mc/s, i.e., 8 to 9mm; (2) a separate and versatile klystron power supply and modulation system; and (3) an independent system of frequency stabilization based on a design due to R.V. Pound. The whole equipment is assembled in two main sections. One is the signal generator unit comprising the klystron, an output meter, a precision calibrated attenuator, and a waveguide hybrid-T circuit in which the frequency of the klystron output is compared with that of a built-in standard reference cavity. The other is a cabinet rack containing both the electronically regulated power supply units feeding the klystron and the Pound stabilizer units which constitute an automatic klystron frequency control system actuated by the magnitude and phase of the correction signal fed back from the hybrid-T circuit. All the millimetre-band components are confined to the separate signal generator unit and all connexions between this unit and the cabinet rack are made by means of plug-and-socket connectors. Because of this, and because the main outputs from the power supply sections are monitored and each independently variable over a wide range, the OA 1000 is not only an e.h.f. signal generator but also a versatile and comprehensive equipment suitable for supplying most types of klystron at present available.

Marconi Instruments Ltd.,
St. Albans,
Hertfordshire.

Metropolitan-Vickers
Null Indicator

THIS 50c/s null indicator is intended particularly for use with high voltage bridges, e.g., Schering bridges, and has a very high rejection factor, of the order of several thousand times, for high frequency corona discharge currents. Its performance at 50c/s is superior to that of single tuned circuit or paralelled-T feedback selective amplifiers since it has a higher bandwidth and greater rejection of third harmonic. The response is substantially flat from 25 to 75c/s and the rejection of 150c/s is 130 times. The instrument, which is an *RC* filter with valve anode impedances replacing some of the resistance elements, is simple to use and free from zero or gain controls; also a variation of ±20 per cent in the value of any of the components is tolerable.

Metropolitan-Vickers Electrical Co. Ltd.,
Trafford Park,
Manchester, 17.

Mullard
Millimicrosecond Photography

THE use of image converter tubes as the shutters of ultra high-speed cameras is now well established. The image of the object to be photographed is focused on the sensitive photo-cathode of the tube. When operating voltages are applied, a duplicate image appears at the opposite end of the tube. To photograph fast transient phenomena, the tube is switched on by voltage pulses synchronized with the phenomena, the actual photographic record being made by an ordinary camera at the viewing end of the tube.

In the past, circuit limitations have fixed the lower limit of exposure at about 30 × 10⁻⁹sec. In the present demonstration, the use of a coaxial pulsing system enables the exposure time to be reduced ten times, i.e., to 3 × 10⁻⁹sec.

In the demonstration, a voltage pulse produced by a very fast spark discharge travels down a coaxial line to trigger on the tube. At the same time, the light generated by the spark is guided by mirrors to the photo-cathode of the image tube. When the light path is lengthened by moving the mirrors, a point is reached where the image of the spark on the viewing screen disappears, because the light arrives at the photo-cathode after the voltage pulse which triggers the tube has died away. By adjusting the length of the light path, the various stages in the formation of the spark can be seen, and the effective exposure may be reduced to about 3 × 10⁻¹⁰sec, the picture on the tube

being visible to the eye and recordable by film. (Light travels 9cm in 3×10^{-10} sec.)

Mullard Ltd.,
Century House,
Shaftesbury Avenue,
London, W.C.2.

Plessey

Computing Components

(Illustrated below)

SHOWN for the first time was a magnetic store drum (*illustrated below*) and input-output buffer units, which are being developed for use with the Plessey payroll computer. The store has a capacity of 100 000 bits in a surface medium of cobalt-rich cobalt-nickel alloy. A track packing of 16 to the inch and a digital packing of approximately fifty to the inch is used. The mumetal heads have an impedance of 25Ω and a playback amplitude of about 10mV. The peripheral velocity of the drum is approximately 900in/sec.

The input and output buffer storage units each store 16 decimal digits. Five such units may be used to store, or punch all eighty columns of a standard Hollerith card using standard equipment. The use of input-output buffer storage allows computing to take place as cards are being read and punched. The individual storage elements in the buffers are dekatrons, and these tubes are used in the arithmetic unit of the computer proper. The power consumption is approximately 250mW per decimal digit for the input buffer and approximately 1W per digit for the output buffer.

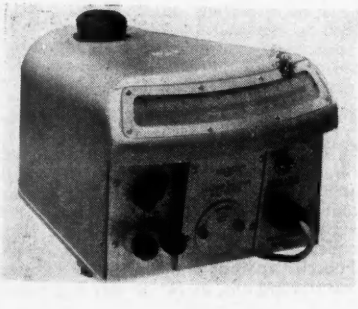
The Plessey Co. Ltd.,
Ilford,
Essex.

Pye

"Scalamp" Megohm Voltmeter

(Illustrated below)

THE usefulness of the pivoted voltmeter is limited in many applications by its comparatively low resistance which can seldom be higher than 20kΩ/V. By use of a suspended galvanometer it is possible to obtain much higher resistances and exhibited was the prototype of a voltmeter having a resistance of 1MΩ/V. A further advantage is the possibility of measuring low voltages and this instrument has ranges as low as 10mV for full-scale deflexion. The scale is approximately 5½in long and the light spot has a hair line which allows readings to be



taken with great accuracy. The specified accuracy is to ±1 per cent of full-scale deflexion and there are 10 ranges from 10mV to 300V. The whole instrument is robust and simple to use. There is provision for shorting the coil automatically when the instrument is turned off and when it is lifted from the bench.

W. G. Pye & Co. Ltd,
"Granta" Works,
Newmarket Road,
Cambridge.

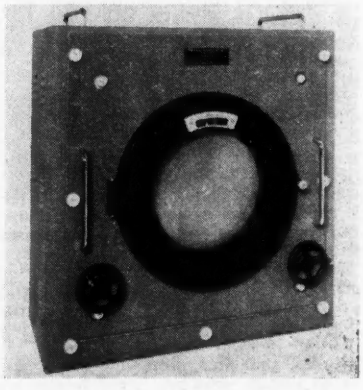
S.T.C.

Radar P.P.I. Simulator

(Illustrated below)

THE "Standard" radar p.p.i. simulator is a simple non-electronic device affording a realistic p.p.i. display for practical radar instructional purposes.

A feature of the apparatus is that all information displayed on the artificial radar screen is prepared and pre-set as a programme of events by the instructor and remains under his full control throughout the period of instruction.



The principle on which the radar trainer operates ensures a high degree of realism in the simulated display. For example, the time-base is formed by a rotating beam or shaft of ultra-violet light activating a coating of television powder on the "tube" face and causing it to fluoresce. Target and other information is superimposed on this time-base by the interposition between the light source and the tube face of a substance giving a more pronounced fluorescence with correspondingly longer persistence. In the version suggested for the Army, nylon thread with globules of thin substance in colourless lacquer provide the moving target traces in association with an ingenious system of pulleys and motors which afford an infinitely variable programme of targets and courses with the choice of two or more speeds. Emulating conventional radar sets at present in service, the simulator is equipped with a cursor for reading off bearings on the tube face and appropriate range markers.

Standard Telephones & Cables Ltd,
Connaught House,
Aldwych,
London, W.C.2.

Sunvic

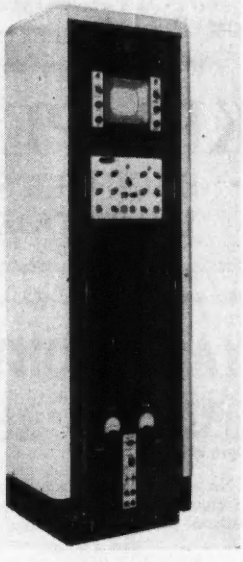
Pulse Height Analyser

(Illustrated below)

THE pulse height analyser is an instrument for the analysis of a complex pulse amplitude spectrum into groups of known height according to their voltage amplitude.

It displays up to a maximum of 120 channels and can store 1 200 binary digits. The design is based on that of Hutchinson and Scarrot (*Phil. Mag. 42*, 792, 1951) and the instrument is made under licence from the N.R.D.C.

An input pulse which is to be sorted passes in turn through a pre-amplifier with a gain of four, a biased amplifier which removes a controllable amount of the base of the pulse, an inverting amplifier of variable gain and a gate circuit and is then fed into a pulse lengthener. A linear sweep circuit generates a voltage which is linear with time and the analyser measures the time interval which elapses between the



beginning of the linear sweep and the instance at which the linear sweep voltage equals the output voltage from the pulse lengthener. This interval is then used to add unity to the appropriate binary number in the display.

The display unit, incorporates the sorting, memory and display circuits, the display being presented on the screen of a cathode-ray tube in the form of a raster of vertical lines, one line for each channel. The count in each channel is represented on a binary scale by an array of brightened dots. Each dot represents a "1" while a space represents an "0". The least significant figure in each channel appears at the bottom of the line and hence the pulse spectrum is approximately plotted on a logarithmic scale by the dots representing the most significant figure in each channel.

A calibration pulse generator is included in the apparatus.

Sunvic Controls Ltd,
10 Essex Street,
London, W.C.2.

BOOK REVIEWS

Electroacoustics
(The analysis of transduction, and its historical background.)

By Frederick V. Hunt. 260 pp. 60 figs. Demy 8vo. Harvard Monographs in applied science, No. 5. John Wiley & Sons, Inc., New York. Chapman & Hall Ltd., London. 1954. Price 48s.

PROFESSOR Hunt's first book contains 235 pages of text, of which the first 91 are a historical survey of the developments in sound transmission and reception. This is fascinating but rather insular, as is common with American texts. True, Henry Hunning's invention (British Patent 3647/1878) of the carbon granule transmitter is mentioned, but not with much enthusiasm; yet this, the basis of all current designs of telephone transmitter, was a far-reaching and revolutionary innovation. No mention is made of Dr. N. W. MacLachlan's moving-coil free cone loudspeaker, which certainly pre-dated the Rice and Kellog patents. This reviewer remembers hearing it in 1924. Nor is P.G.A.H. Voigt's work on capacitive transmitters described. The reader may feel that about 15s. is rather a lot to pay for this collection of memoirs and details of patent litigation.

The second chapter examines electromechanical coupling in general terms, motional impedance and the effect of frequency on mechanical impedance being introduced as a series of vectors relating phase angle to magnitude in a general sense, so that the data is applicable to any coupled vibrating system, e.g., string oscillographs.

In the next chapter the difficulties of relating the antireciprocal nature of electromagnetic systems to the principle of reciprocity for coupled electromechanical systems leads to a discussion of the shortcomings of existing sign conventions in such analyses, and allows the author to introduce a new form of space operator to bring analytical symmetry into antireciprocal cases involving magnetic fields. This concept permits a unified treatment for all types of electro-mechanical coupling and is certainly ingenious if difficult to manipulate; it is observed that the author does not seek to apply this method very much in the book.

Chapter IV is a long and detailed analysis of transducer performance on an admittance basis as contrasted with an impedance basis. One is left with the feeling that the author recognizes that experimental requirements really dictate which approach is of most value.

Chapter V is an excellent discussion on electrodynamic loudspeakers. Unfortunately the only valid information relates to the low-frequency response range. Only a conjectural approach is made, covered in but two pages, to the vexed problems of the behaviour above the frequency at which the cone ceases to act as a solid piston. The author says, "Eliminating these irregularities in response throughout the middle and upper range of frequency is one of the major and not yet fully solved problems of modern loudspeaker design." It is clear that this most important part of the range does not yield to any of the theories developed in this book; rather disappointing, this is something we all want to know a lot more about.

In Chapter VI we come to an excellent and most refreshing analysis of electrostatic loudspeakers. This promising alternative to the conventional moving coil system could profitably be re-examined since the advent of new dielectric materials, sputtering techniques, etc.

The last chapter purports to describe electromagnetic transducers of the gramophone pick-up type, but is really devoted to an analysis of the ring diaphragm telephone receiver. It seems unfortunate that other patterns of transducer were not included, since the title of the monograph is very broad and the inference is that the inclusion of all types might be anticipated.

The book is up-to-date, stimulating in parts, and contains much valuable food for thought. It is written in a scholarly style and a second edition should give Professor Hunt the opportunity to include further examples of well-known methods of transduction which would greatly increase the present limited appeal.

ALAN DOUGLAS.

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Zirkonium Seine Herstellung Eigenschaften und Anwendungen in der Vakuumtechnik (Zirconium — Its production, properties and applications in vacuum technique)

By Werner Espe. 174 pp. 14 figs. 20 tables. Demy 8vo. C. F. Winter'sche Verlagshandlung, Fuessen/Bayern. 1953.

THE author of this little monograph is in charge of development of the now nationalized electronic valve manufacture in Czechoslovakia. He is the co-author (with Knoll) of that well known standard work *Stoffkunde der Hochvakuumtechnik* (Materials for High Vacuum Technique) which appeared in 1936. In the slender book under review he gives a comprehensive, competent and very valuable survey on the production and the properties of zirconium and its various applications in the manufacture of vacuum tubes. After some brief introductory remarks about how and where the raw material is found, the production of zirconium powder, of zirconium-hydride powder and of compact, ductile zirconium are described in detail and illustrated. The physical and chemical properties of the metal are discussed and particularly those which make it suitable for gettering purposes. A brief section deals with the manufacturing of intermediate products of zirconium, like sponge, brickets, ingots, disks, sheets, bars and wires. Special precautionary methods are described which must be applied in order to reduce fire risks due to the high inflammability of zirconium power. The second part of the book deals in detail with the application of the metal in vacuum technique and in particular with the methods applied for producing gettering layers by painting, dipping or spraying or by cataphoresis.

A special feature of the book is the large number of tables containing the most important physical, chemical and mechanical properties of the material and some recipes in concise form for producing the suspensions of zirconium powder or zirconium hydride as used in the various gettering processes.

A bibliography and a subject matter index conclude the book which will be welcomed by all those interested in gettering technique.

R. NEUMANN.

Active Networks

By V. C. Rideout. 485 pp. 75 figs. Demy 8vo. Constable & Co. Ltd. 1954. Price 42s.

THIS is a useful and well balanced textbook on valves and valve circuits for students who possess a fair mathematical background. Although the author devotes space to explain the principles of four terminal network analysis, Fourrier analysis and the use of Laplace transformations, as far as this is possible

in a book of this size, he does assume a fair knowledge of passive networks, Bessel functions and the use of determinants.

Each chapter concludes with a most comprehensive collection of references, mostly to American books and journals unfortunately, and a set of problems of a practical type. There are about 150 problems in the book and a collection of valve and transistor characteristics are provided which are required for some of the solutions. No answers are available but a number of numerical problems are worked out in the text.

The jacket states that transistors are dealt with in considerable detail although there are in fact only fourteen pages on this subject distributed throughout the book. References to magnetic amplifiers and position controlled servo-mechanisms are brief.

In the chapter on power amplifiers the usual discussion arises on the optimum value of load for a power output triode. A value of load resistance equal to twice that of the anode slope resistance of an ideal valve is determined once the h.t. is fixed and is not a compromise due to non-linear characteristics as the author suggests.

Again, when dealing with phase shift oscillators, the author chooses to analyse the case where the valve load resistance is small compared with the input impedance of the phase shift network. This treatment leads to values of frequency and attenuation that may be materially at variance with practically observed values.

Relationships between f.m., p.m. and a.m. are well illustrated. Modern techniques of producing wide band f.m. and p.m. using the serrasoid modulator and klystron contrast clearly with earlier systems such as Armstrongs. One must, however, move on to the chapter on noise and information theory to discover the improvement in signal-to-noise ratio which is a virtue of wide band f.m. and the further improvement pre-emphasis affords.

Errors in the text are very few and detract in no way from a work which manages to cover a wide field in a stimulating manner.

H. HENDERSON.

Studio Engineering for Sound Broadcasting

Edited by J. W. Godfrey. 208 pp., 108 figs. Demy 8vo. Iliffe & Sons Ltd. 1955. Price 25s.

THIS book has been compiled for the primary purpose of training BBC technical staff in the general principles underlying operational procedures at the Corporation's studio centres. It is now made available outside the Corporation in the belief that broadcasting staff throughout the world, on both the engineering and non-engineering sides, will find a great deal of interest and practical value in its pages.

All six authors are members of the BBC Engineering Division, and each is a specialist in his field. The technical level is practical rather than academic and should present no difficulty to readers.

Mathematics of Engineering Systems (Linear and Non-Linear).

By D. F. Lawden 388 pp., 50 figs. Demy 8vo. Methuen & Co. Ltd. 1954. Price 30s.

THE techniques described in this book are very carefully explained in detail and copiously illustrated by a useful selection of examples from electrical engineering. After an introductory chapter on mathematical accessories—readers are assumed to know the first part of the mathematics for an engineering degree—the author discusses the solution of linear differential equations with constant coefficients, using the D-operator, Laplace transform and then complex variable for response curves, but not dealing with inverse transforms. There is a chapter on Fourier analysis leading up to Fourier transforms. The final chapter describes very well the now standard methods of dealing with the non-linear equations of Van der Pol and Duffing. My real criticism of the book is that the title is completely misleading. There are vast numbers of engineering systems whose mathematics are not described: for example, Rayleigh's method and partial differentiation are not mentioned. A further criticism concerns the presentation of methods for non-linear equations. The methods developed so far, excellent though they are, are severely limited in their application, unless numerical, and this should be made quite clear. Probably the only reason for spending so much time on the mathematics is that this is one field where the beginner can be brought into contact with fresh developments in the mathematics.

G. J. Kynch.

The Gyroscope Applied

By K. I. T. Richardson. 384 pp., 120 figs. Royal 8vo. Hutchinson's Scientific and Technical Publications. 1954. Price 30s.

THIS is an excellently produced book based on "The Gyroscope and its Applications" which was published in 1946 when secrecy restrictions prevented reference to many interesting achievements and possibilities. This new book has been almost entirely rewritten, describing much that is new but at the same time incorporating most of the information given in the first version, although this is presented in a different manner and in some cases from a different view point.

Unlike the first book which was written by several authors, this is the work of one man who is closely associated with the development of many forms of gyroscopic application in many different spheres. It is believed to be one of the very few books that embraces in one cover as many of the different types of application as possible ranging from small intricate aircraft instruments to large engineering projects, such as the roll stabilizers for 40 000 ton liners.

The Physics of Particle Size Analysis

217 pp. Royal 8vo. The British Journal of Applied Physics Supplement No. 3. The Institute of Physics. 1954. Price 35s.

THIS supplement presents the papers of the eight sessions of a conference held in the University of Nottingham from 6-9 April, 1954. Comments are included at the end of each paper, together with the authors' replies.

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LETTERS TO THE EDITOR

(We do not hold ourselves responsible for the opinions of our correspondents)

Feedback Amplifiers

DEAR SIR,—Despite the opening remarks in his letter in the March issue, Mr. Moorby makes a rather confusing analysis of the simple feedback amplifier.

First, the symbol Z_1 is used to denote two entirely different impedances (Figs. 2 and 3) and then in deriving the expression for g, e_{1a} and E_{1a} are interchanged although they are totally different voltages. Z_2 is simply left by the wayside! Also, the terminals A-B in Fig. 3 cannot be regarded as the input terminals of the circuit.

However, it so happens that the Z_2 of Fig. 2 can often be omitted without modifying the overal gain appreciably (though not in an exact analysis—and Mr. Moorby makes no assumptions regarding the value of Z_2). This is easily shown as follows with reference to Fig. 4.

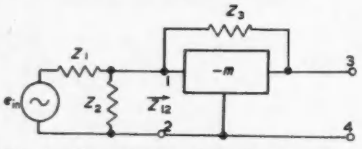


Fig. 4. Rearrangement of feedback amplifier

From Fig. 4 $Z_{12}=Z_3\,(1+m)$. This follows since the voltage across Z_3 is $(1+m)e_{12}$ and the input current due to e_{12} is therefore $\dfrac{(1+m)e_{12}}{Z_3}$

Now Z_{12} is normally a very low impedance which allows Z_2 (being in shunt with Z_{12}) to be neglected in many cases. The overall gain (g) then becomes:

$$g \simeq -\,m\left(\frac{Z_{12}}{Z_1+Z_{12}}\right) \quad \ldots\ldots\ldots\ldots (1)$$

$$\simeq \frac{-m}{Z_1(1+m)/Z_3+1} \quad \ldots\ldots (2)$$

If Z_2 is not much larger than Z_{12} it is a simple matter to modify the value of Z_{12} in equation (1) to take account of the shunting effect of Z_2. This gives an exact expression for g:—

$$g = \frac{-m}{(1/Z_2+(1+m)/Z_3)} \quad \ldots\ldots\ldots (3)$$

In many cases Z_2 may be chosen to provide the correct d.c. conditions without appreciably affecting the overall gain; Z_1 and Z_3 being chosen to fix the overall gain and with regard to loading of the source e_{1a}, loading of the output or by frequency response effects. In some cases Z_1 may include or consist entirely of the source impedance of the generator e_{1a}, in which case only Z_3 need be determined to fix the gain.

No assumptions regarding the value of Z_3 need be made since the value of m can be modified to take Z_3 into account; Z_3 behaving as a load of $m/1+m\,Z_3$ on the amplifier. Usually m$\gg$1 and this approximates to Z_3.

Turning to output impedance, Mr. Moorby's remarks concerning maximum power output may be very confusing to the inexperienced. He implies that the maximum power transfer theorem does not hold for feedback amplifiers. If e_{1a} is fixed at a sufficiently low value, so that the amplifier is never overloaded, and the load impedance (Z_L) varied, then maximum power output is obtained when $Z_L=Z_O$ regardless of the application of feedback. It is true, of course, that maximum available power is obtained with Z_L equal to the appropriate optimum (not necessarily R_a) and with e_{1a} increased to fully load the stage, but a linear analysis made without regard to purely practical limitations such as available current swing, d.c. operating points, etc., cannot take this into account and one could define Z_O as being equal to the load required for maximum power output—"linear operation" understood.

Such operation is of course taken for granted in Mr. Moorby's own analysis, where he considers G_O as "the overall mutual conductance of the amplifier at the short-circuited output terminals." This measurement would require a very low value of e_{1a}, and must be done in a manner which will not disturb the d.c. operating conditions.

Mr. Moorby points out a useful approach in quoting $Z_O=g_\infty/G_O$ (I assume gD was a misprint for g_∞) but he does not make clear that G_O is the ratio of the short-circuit output current to e_{1a} and that it depends on Z_1, Z_2 and Z_3. In fact he falls into his own trap in his last example when he quotes $G_O=G_m$ which is obviously not true. I am also puzzled in this example as to the significance of n_∞ (again I assume $m=22.3$ is a misprint for $n=22{\cdot}3$). This figure is used instead of g in calculating Z_O; G_O being incorrectly stated as $=G_m$.

G_O is easily derived with reference to Fig. 5.

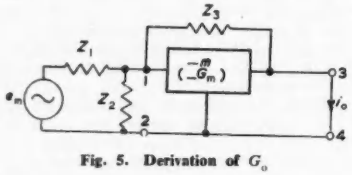


Fig. 5. Derivation of G_o

$$G_O \mp i_o/e_{1a} = \frac{-e_{12}(G_m-1/Z_3)}{e_{1a}}$$

$$= -\,\frac{(G_m-1/Z_3)}{1+Z_1/Z_3+Z_1/Z_2}$$

$$\simeq -\,\frac{G_m}{1+Z_1/Z_3+Z_1/Z_2}$$

(since in general $G_m \gg 1/Z_3$) — (4)

It is interesting to note that $Z_O\,(=g/G_O)$ is a function of Z_2 unless $Z_2 \gg Z_1$ whereas the overall gain may be substantially independent of Z_2 even when $Z_2 < Z_1$ providing $Z_2 \gg Z_3/(1+m)$, which is often true.

Finally, referring back to Mr. McDonnell's letter in the December issue, it will be seen that for the simple "see-saw" phase-splitter (anode-follower) where $Z_1=Z_3$ and $Z_2 \gg Z_1$ then providing $m \gg 1$ so that $g \simeq 1$ then $Z_O=g/G_O=1/G_m/2=2/G_m$, assuming the output is taken direct from the anode. It will be seen that the presence of the two R's in Mr. McDonnell's less usual circuit modifies G_O so that this expression does not hold.

Yours faithfully,
C. W. WARD,
Plymouth,
Devon.

Amplifier Output Impedance

DEAR SIR,—I regret that in reading the proofs of my letter in the March issue, I missed some small errors, mainly in suffixes. May I therefore briefly correct the basic formulae.

(1) Suffixes, o refers to zero load, ∞ refers to infinite load, f to a finite (non-zero) load.

(2) m is the gain of the amplifier measured from the grid to the "hot" end of the load, i.e. for a single stage, from grid to anode. g is the gain from the input terminal to the load. Obviously, if the impedance between the grid and input terminal is negligible, $m=g$. Please note, that to agree with Fig. 3, in the derivation of equations for m, n, ∞, g, the first equation in the last paragraph of column one should read

$$\frac{1-E_{1a}}{Z_1} = \frac{m-1}{Z_2}$$

We then get

(a) $g = \dfrac{mn}{1+n-m}$ (b) $n = \dfrac{g(m-1)}{g-m}$

(c) $m = \dfrac{g(n+1)}{g+n}$

I should like to modify my definition of the distinction between voltage and current feedback, as I find some small ambiguities in my original statement. I think that to get a true definition, we must proceed as follows.

Consider Fig. 4, which is a development of Fig. 3 of my original letter. Here, e A.B. is the input, and e 3·4 the output, and 1 is the grid of the first stage of the amplifier since $g=e_{3.4}/e_{AB}$ and $m = e_{2.4}/e_{1.2}$ both of which may be measured. We can determine $n = \dfrac{g(m-1)}{g-m}$ (ante (b)).

In the case of current feedback, n varies with load impedance, while in the case of voltage feedback, n is independent of load impedance. This I now consider is the only concise and sufficiently rigorous definition available.

In my earlier letter I put $G_o=G$. This is incorrect as $G = G\,\dfrac{n}{1+n}$ as will

be obvious if we consider the anode earthy. The grid potential is then $E_{1a} = \frac{n}{1+n}$ whence $G_o = G\frac{n}{1+n}$. This gives $Z_o = \frac{-m_\infty(n+1)}{G(-m_\infty+n+1)}$

Perhaps, having reduced the problem by the equations, to which we add $Z_o = g_\infty/G_o$, we may assume that the distinction is now dedundant, and that "feedback" alone is a sufficient statement, since if we attempt a definition in general terms, it is not always useful, and all we

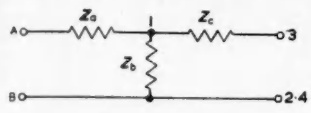


Fig. 4. Development of Fig. 3 (April)

should really be concerned with is overall gain (g) and output impedance (Z_o).

Yours faithfully,

H. MOORBY,

Farnborough, Hants.

The Effect of Instrument Impedance in the Measurement of "Quality Factor" by Parallel Resonance

DEAR SIR,—When making electrical measurements, instrument impedances usually affect circuit behaviour, however slightly. Here is one case where they have no overall effect whatever. In the circuit shown the aim is to find Q the Quality Factor for the imperfect physical inductance L. An a.c. voltage-generator maintains a constant voltage output E of any chosen angular frequency, ω. C represents the setting of a decade capacitance box and R that of a non-inductive decade resistance box. The losses in the capacitance C are assumed to be negligible compared with those of inductance L.

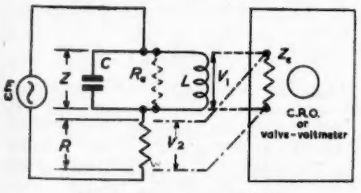


Fig. 1. Measurement of Q

With the measuring instrument out of circuit and at the resonant frequency $\omega_n = 1/\sqrt{(LC)}$, the impedance Z is purely resistive and equal to R_e the loss resistance of L at frequency ω_n.

Quality Factor is defined at $Q = L\omega_n/R_e$. If V_e and V are the true voltages across R_e and R respectively

$$R_e = R.\ V_e/V \quad \ldots\ldots\ldots\ldots\ (1)$$

The Quality Factor Q is, therefore,

$$Q = (L\omega_n/R)(V/V_e) \quad \ldots\ldots\ldots\ldots\ ((2)$$

As L ω_n and R are known, Q can be computed from equation (2) if the voltage ratio V/V_e is known.

To measure the ratio of voltages across R_e and R, an instrument such as a cathode-ray oscillograph or a valve-voltmeter might be used. Whatever the instrument, it will in general have an input impedance Z_c having both reactive and non-reactive components. The connexion of the instrument across R_e and R in turn as shown by dotted and chain-dotted lines will result in the recording of voltages V_1 and V_2 which will differ from V_e and V respectively. It is shown below that provided the circuit is resonated by some means without the measuring instrument in circuit

$$V_2/V_1 = V/V_e \quad \ldots\ldots\ldots\ldots\ (3)$$

If the resonance at frequency ω_n is detected by the measuring instrument by noting when the adjustment of C makes V_1 a maximum, then the above result still holds providing Z_c is non-reactive.

It can be seen from equations (2) and (3) that

$$Q = (L\omega_n/R)(V_2/V_1) \text{ for all values of } Z_c \quad \ldots\ldots\ldots\ldots\ (4)$$

This is proved as follows. In the dotted position for measuring V_1, the line-current i_1 is

$$i_1 = \frac{E}{\frac{1}{(1/R_e + 1/Z_c)} + R}$$

$$\therefore\ V_1 = \frac{\frac{E}{(1/R_e + 1/Z_c)}}{\frac{1}{(1/R_e + 1/Z_c)} + R} = \frac{E}{1+R(1/R_e+1/Z_c)+1}$$

In the chain-dotted position for measuring V_2 the line-current i_2 is

$$i_2 = \frac{E}{R_e + \frac{1}{(1/R+1/Z_c)}}$$

$$\therefore\ V_2 = \frac{\frac{E}{(1/R+1/Z_c)}}{R_e + \frac{1}{(1/R+1/Z_c)}} \qquad \frac{E}{R_e(1/R+1/Z_c)+1}$$

Hence

$$V_2/V_1 = \frac{1+R(1/R_e+1/Z_c)}{R_e(1/R+1/Z_c)+1}$$

$$= R/R_e\left[\frac{R_eZ_c+R(Z_c+R_e)}{R_e(Z_c+R)+RZ_c}\right] = R/R_e \quad \ldots\ldots\ldots\ldots\ (5)$$

By comparing equations (1) and (5) equation (3) is proved. Hence equation (4) follows from equations (2) and (3).

Yours faithfully,

J. P. DUNCAN,

Engineering Department,
University of Manchester.

Computers and Computors

DEAR SIR,—I am writing with regard to recent letters on the spelling of "computer/or". I don't think the matter worth prolonging in print, as my point of view is not altogether one of great importance to the practising computer/or engineer.

The suffix -er is the normal English suffix for the agent, thus:

Computer, one who or that which computes.

Commenter, one who comments.

The suffix -or is the normal Latin suffix for the agent, thus:

Computator, from "computare" = computer,

Commentator, from "commentari" = commenter,

Commentor, from "comminisceri" an inventor,

usually in the sense of a faker, but never adopted into English. I cannot agree that "commentor" is a correct form of "commentator". It has been used in this sense, as a variant spelling of "commenter", see the OED, but, to quote A. P. Herbert, the dictionary "is a pusillanimous work, preferring feebly to record what has been done rather than stating firmly what should be done". Notwithstanding this, the OED will have nothing of "computor"—"bad spelling of 'computer'", and from the purely classical standpoint one has to agree.

The case for "computor", I therefore take it, is not one of good philology but necessity for the distinction to be invented where none previously existed. I submit that there is still no necessity. If a context is such as to leave one in any doubt, it should be rewritten, rather than having to rely on an inaudible distinction to make the matter clear.

(I should, parenthetically, remark that "computor" is not, nor is it ever made out to be, part of the systematic terminology that has given us such philological horrors as "impedance", which if it had to be a Latin word with a Latin tail would have been "impedience"—compare "expedient".)

As regards a distinction which some claim by which -er is a person and -or a thing, I know of no other example, except that I suppose that the wartime underground movement wasn't made up of resistors! Indeed, I am not aware of any significant use of the suffix -or in English (as opposed to in words of Latin origin taken over intact) except in the electronics use of "a component embodying -ance", and it is manifest that "computor" is indefensible on this ground.

Perhaps there is a case for the defence of "computor"—if so I should like to hear it. I have a difficult enough time in the Cambridge computer world persuading people that "program(me)" doesn't mean anything like what the Greeks meant by it—a public notice—but what the French adapted it to mean, and so that there is a case for continuing to spell it as the French do and most of the English, if not the Americans.

Yours faithfully,

JOHN LEECH.

King's College,
Cambridge.

Several other letters on this subject have been received but we feel that the one printed above summarizes the matter fairly and this correspondence is now closed. In view of the arguments put forth (and with which Mr. Puckle, our original contributor on this subject, is now in agreement) the spelling in this journal will be changed to computer.—EDITOR.

Short News Items

The Governors of The College of Aeronautics announce the creation of a Department of Aircraft Electrical Engineering and the appointment of Mr. G. A. Whitfield as Professor and Head of Department. Mr. Whitfield will take up his appointment on 1 June. He is at present head of the Controlled Weapons Division in the Armament Department at the Royal Aircraft Establishment, Farnborough. This appointment is in fulfilment of the Governors' policy of expanding the Electrical Section of the Department of Aircraft Design into a full teaching department.

Metropolitan-Vickers Electrical Co Ltd has endowed four Post-Graduate Bursaries in Electrical and Mechanical Engineering, each of the value of £400 per annum, in the University of Manchester. Two of these bursaries will normally be tenable in the Faculty of Technology of the University at the Manchester College of Technology. The Company has also endowed three similar bursaries tenable in the Mechanical and Electrical Engineering Departments at the Imperial College of Science and Technology, London. A particular purpose of these bursaries is to encourage graduates in physics and mathematics to undertake post-graduate study or research in engineering in preparation for entry into the electrical industry.

The Royal Society recently elected 25 persons into the Fellowship, among whom were the following. D. R. Bates, Professor of Applied Mathematics, The Queen's University, Belfast. S. Devons, Professor of Physics, Imperial College of Science and Technology, London. A. C. B. Lovell, Professor of Radio Astronomy, The University of Manchester.

Export Packing Service Ltd have opened a new Packing Design and Development Department at the Chipping Warden centre. There are depots at Banbury, Sittingbourne, Merthyr Tydfil and Cardiff.

Aero Research Ltd of Duxford, makers of "Araldite" epoxy resins, state that greatly increased output of these products has made it possible to reduce manufacturing costs and, with them, the prices at which "Araldite" can be purchased. These reductions apply to nearly all forms of the resin.

St. Erik's Fair, Stockholm. will be held this year from 27 August-11 September. Last year twenty-nine countries participated, the average attendance being 400 000, including 80 000 trade buyers.

The British Plastics Convention will be held at the National Hall, Olympia, from 1-11 June. Details may be obtained from the Press Officer, British Plastics Federation, 11 Garrick Street, London, W.C.2.

The Board of Extra-Mural Studies, University of Cambridge, announce that a Summer School in programme design for automatic digital computing machines will be held in the University Mathematical Laboratory at Cambridge during the period 12-23 September. It will be along the same lines as those held previously. A detailed syllabus and form of application for admission may be obtained from Mr. G. F. Hickson, Secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge, to whom the completed application form should be returned by 15 June.

The University of Cambridge is also arranging a third course for managers in industry. It will be held in Madingley Hall from 27 June to 22 July, and will be open to managers who have some years' experience in industry and commerce and are under the age of 40. Firms can obtain details from Mr. G. F. Hickson at the address mentioned above.

The Radio Industry Council announce that exports of British radio equipment reached new high levels in 1954. The provisional value is over £29 100 000. This is £3 300 000, more than 12 per cent, higher than the value for 1953, the previous highest figure.

W. Bryan Savage Ltd., have appointed John Ould Ltd., of 389 Fifth Avenue, New York 16, N.Y., to act as their sole concessionaires for the United States of America. This new British enterprise has been formed to operate as a sales organization for manufacturers of electronic and allied equipment in this country. American inquiries for W. Bryan Savage Ltd. products should be sent to Mr. Howard M. Layton, Sales Director, at the address mentioned.

The BBC announces that the first of its new v.h.f. transmitting stations, using Frequency Modulation, will be brought into service at Wrotham, Kent, on 2 May. The new station will transmit the three BBC programmes, the Light Programme on a frequency of 89·1Mc/s, the Third Programme on 91·3Mc/s, and the Home Service on 93·5Mc/s. The effective radiated power will be 120kW in each case, and the transmissions will be horizontally polarized. The station will serve the London area and South-East England within a range of about fifty miles.

Mr. Isaac Shoenberg has been appointed a Director of Electric and Musical Industries Ltd. Mr. Shoenberg has been eminent in the research and development of radio for fifty years. He has been with E.M.I. since its formation in 1931. Last year he was awarded the Faraday Medal for his outstanding contribution to the development of High Definition Television.

The Ministry of Supply announces that Mr. C. J. Carter has been promoted to Deputy Chief Scientific Officer and has been appointed Director of Instrument Research and Development.

Air Marshal Sir Victor Goddard, K.C.B., C.B.E., has joined Elliott Brothers (London) Ltd as an Assistant (Air) to the Managing Director.

Mr. R. L. S. Saunders has been appointed Assistant Engineer-in-Chief of Cable and Wireless Ltd.

Mr. J. P. A. Meldrum and Mr. R. H. S. Turner have been appointed Directors of Metropolitan-Vickers Electrical Co Ltd.

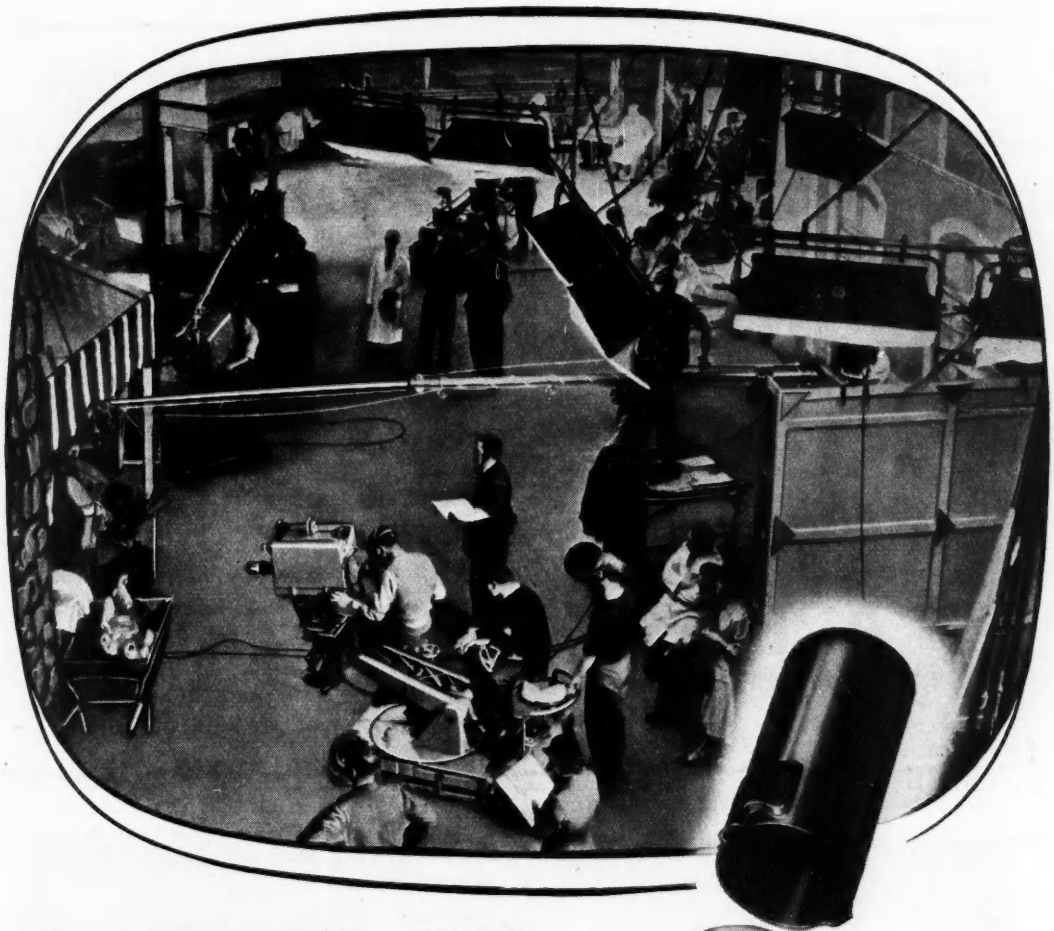
The Independent Television Authority have made the following appointments. Mr. A. M. Beresford-Cooke, Senior Planning Engineer. Mr. R. C. Harman, Superintendent Engineer (Operations and Maintenance). Mr. W. N. Anderson, Senior Lines Engineer.

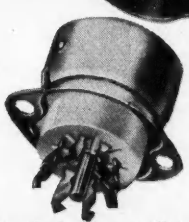
Mr. H. T. Greatorex is now Assistant Head of the Engineering Information Department of the BBC. Mr. T. P. Douglas has been appointed Engineer-in-Charge of the Sutton Coldfield Television Station.

Mullard Ltd exhibited electronic equipment and electron tubes at the recent exhibition of the Institute of Radio Engineers in New York. Some of the exhibits represented the latest developments of British electronic research.

The Council of the Radio and Electronic Component Manufacturers' Federation recently elected Mr. C. M. Benham as Chairman in succession to Mr. W. F. Randall. Mr. Benham is Managing Director of Painton & Co Ltd, Kingsthorpe, Northampton. Mr. S. H. Brewell, Chairman and Managing Director of A. H. Hunt Capacitors Ltd, was elected Vice-Chairman. Mr. Hector V. Slade remains Honorary Treasurer.

Erratum. In the description of "A Very High Speed Camera" on page 153 of the April issue the frame rates given in the table should read 2×10^6, 1×10^6, etc., and not 2×106, 1×106, etc.





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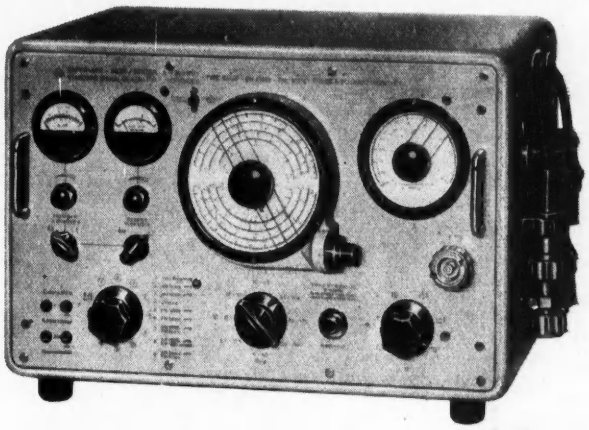

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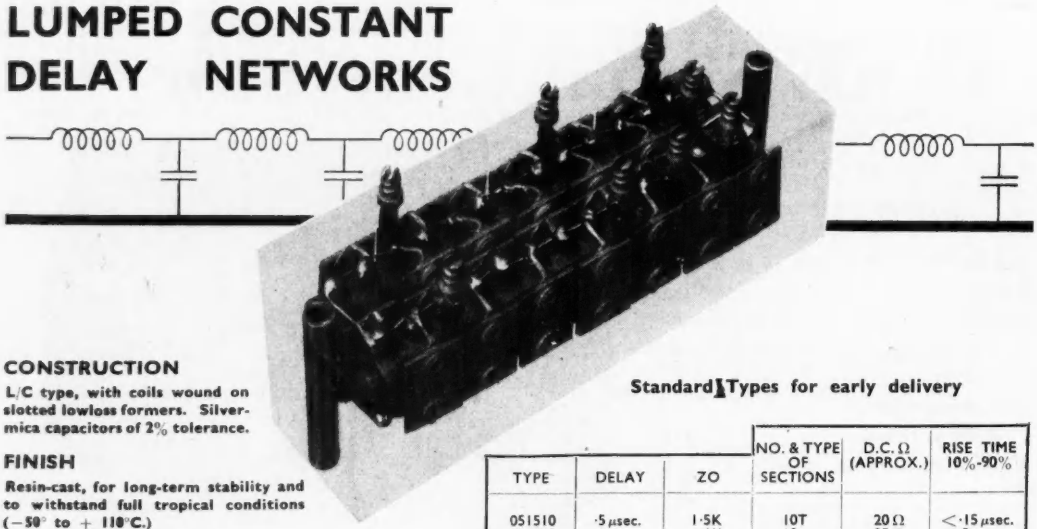

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202010	2 ,,	2K	10π	110 Ω	<·35 ,,
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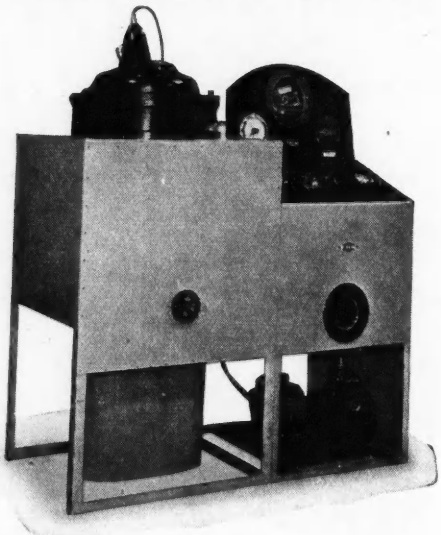

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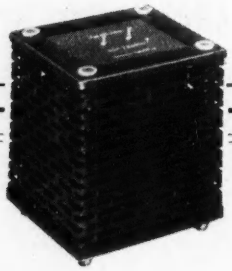

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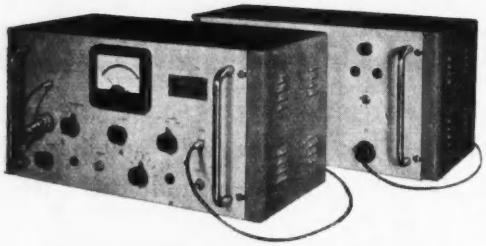

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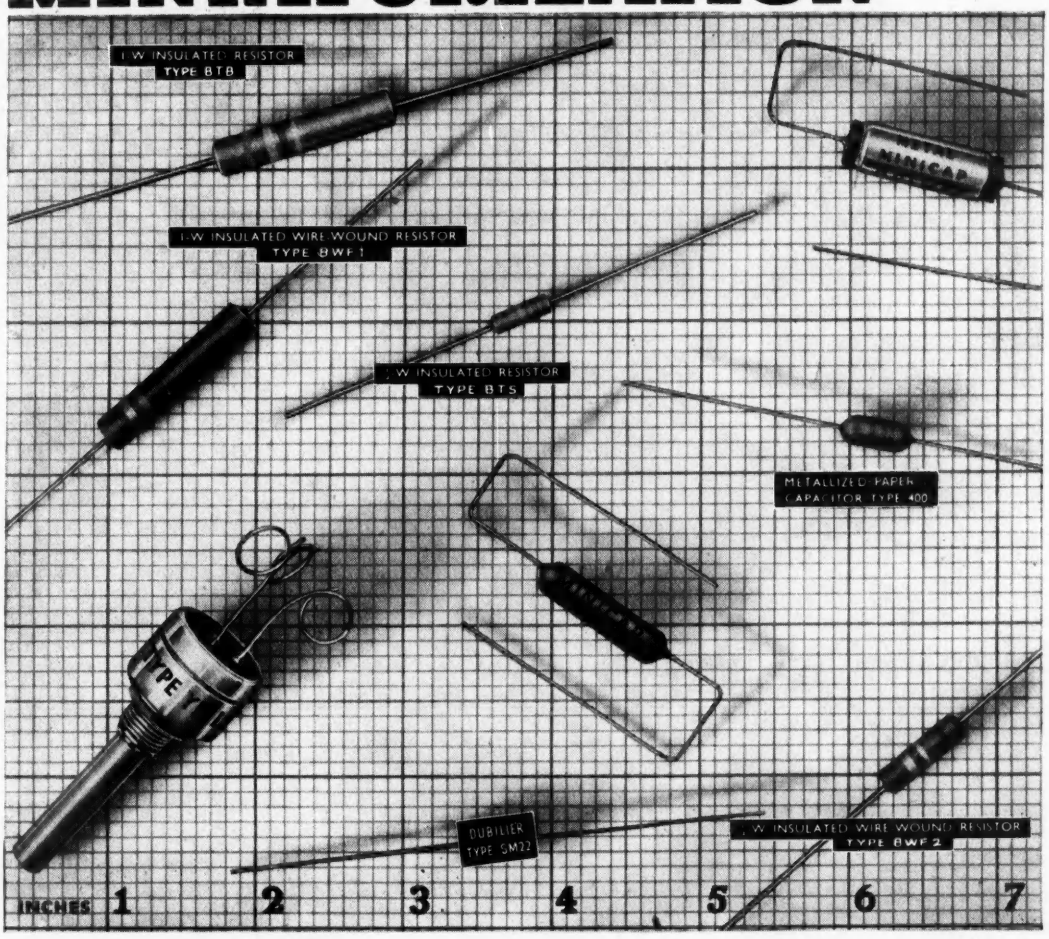

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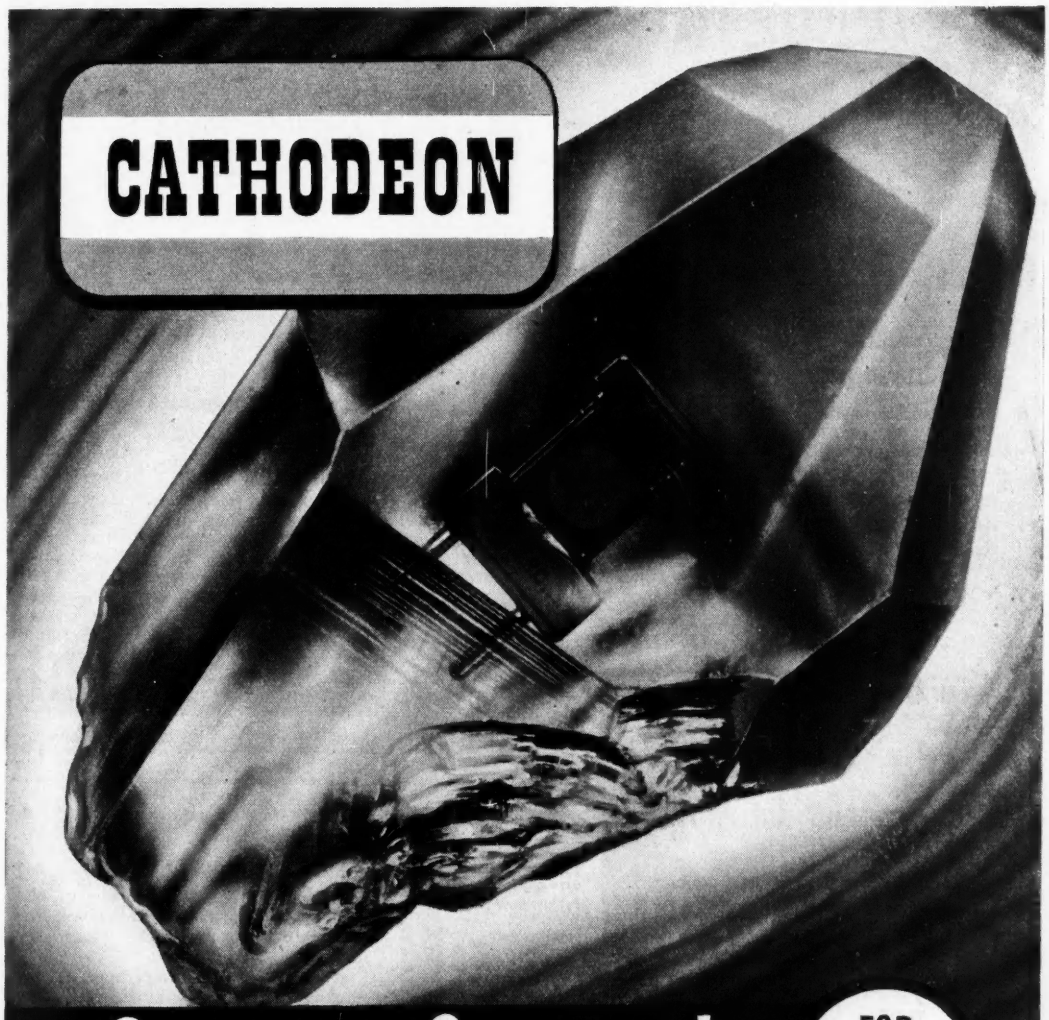

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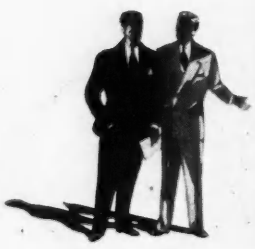

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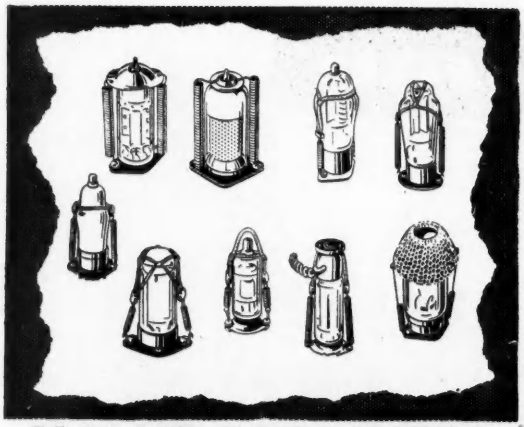

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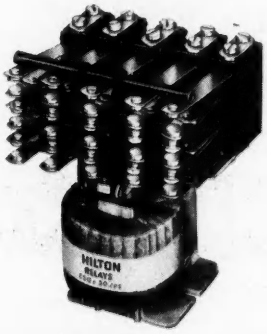

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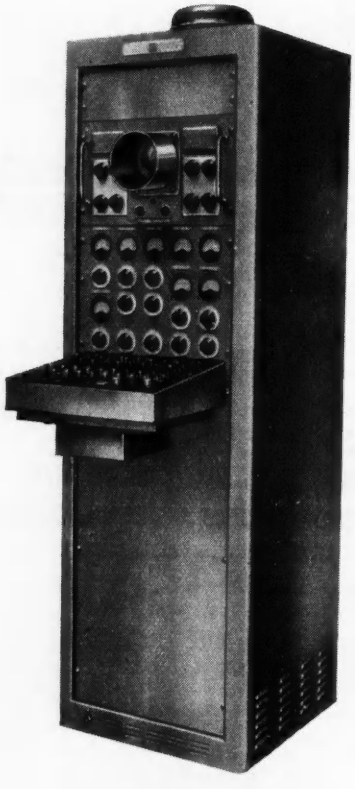

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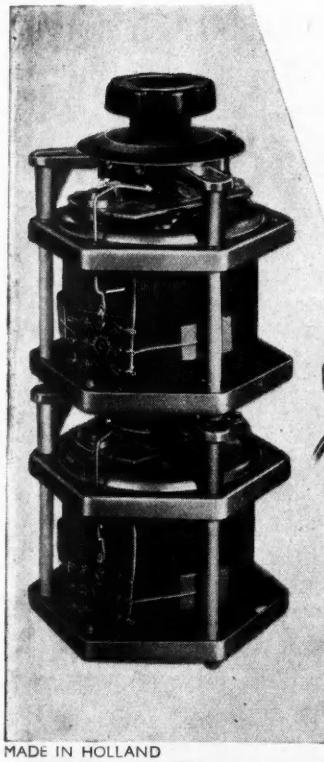

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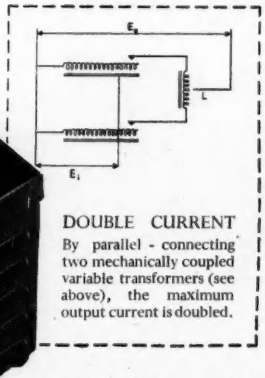

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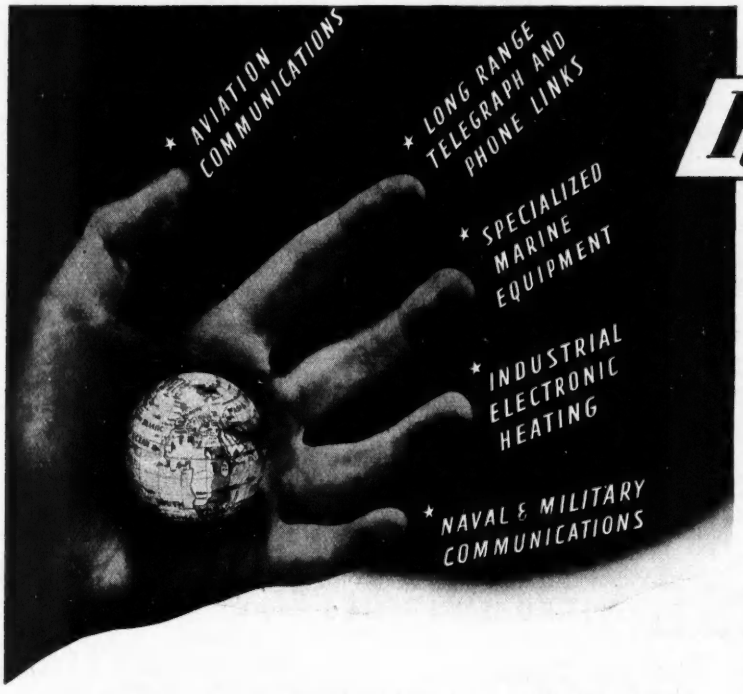
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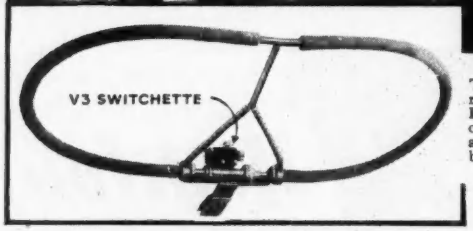

The neck switch with cover removed to show how the Burgess Micro Switchette is operated by the elliptical actuator when the head is bent forwards.

We are indebted to the Director of the Grassland Research Institute, Hurley, nr. Maidenhead, Berks, for permission to give publicity to this valuable work for agriculture and the nation.

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To obtain data on bovine reaction to various types of grazing, the Grassland Research Institute at Hurley have designed and produced ingenious automatic recording equipment which is harnessed to grazing bullocks in the manner illustrated above. Certain tell-tale movements of the animals are carefully recorded to provide precise data with which to build up complete diaries of the day to day happenings in their lives.*

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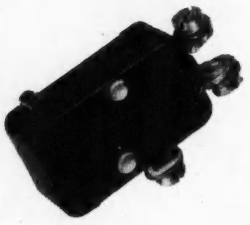

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★ *CANAWAY, R. J., RAYMOND, W. F., and TAYLER, J. C. The automatic recording of animal behaviour in the field. Electronic Engineering* 27 (*April* 1955).

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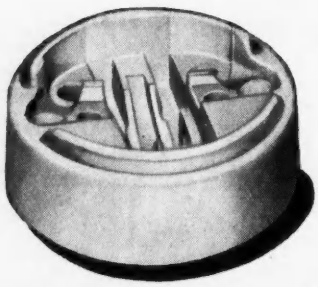

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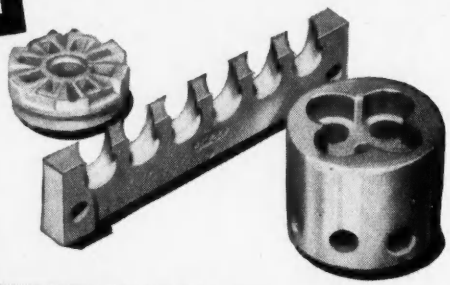

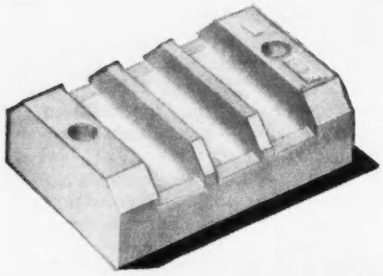

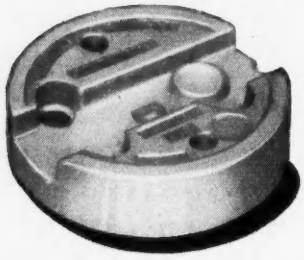

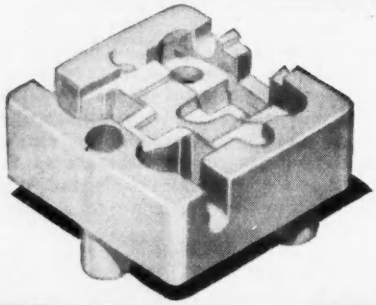

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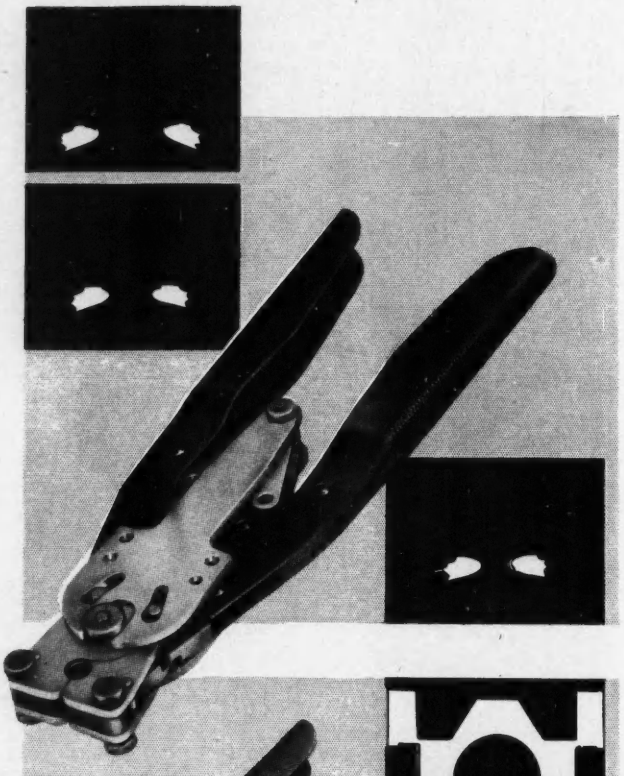

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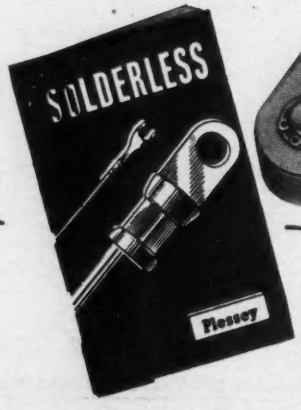

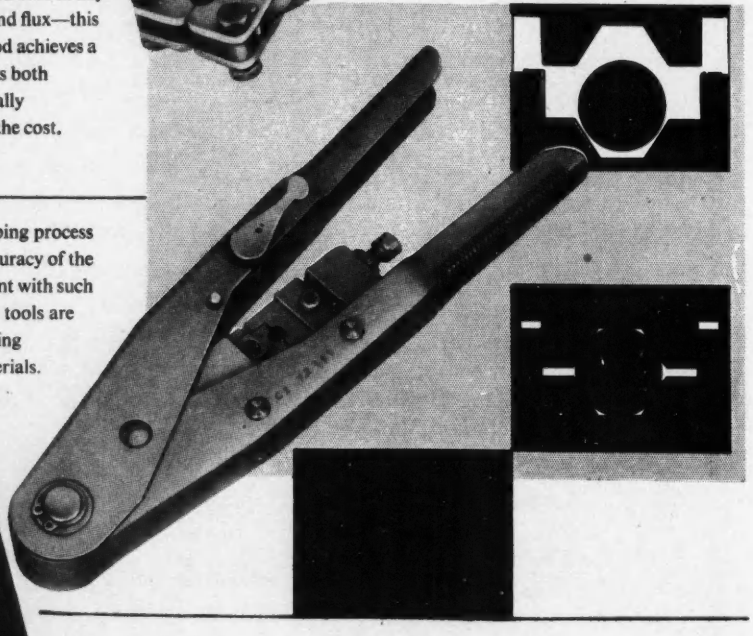

Plessey publication 753/1 contains extensive details of these tools and their application. A copy will be sent to manufacturers free, on request.

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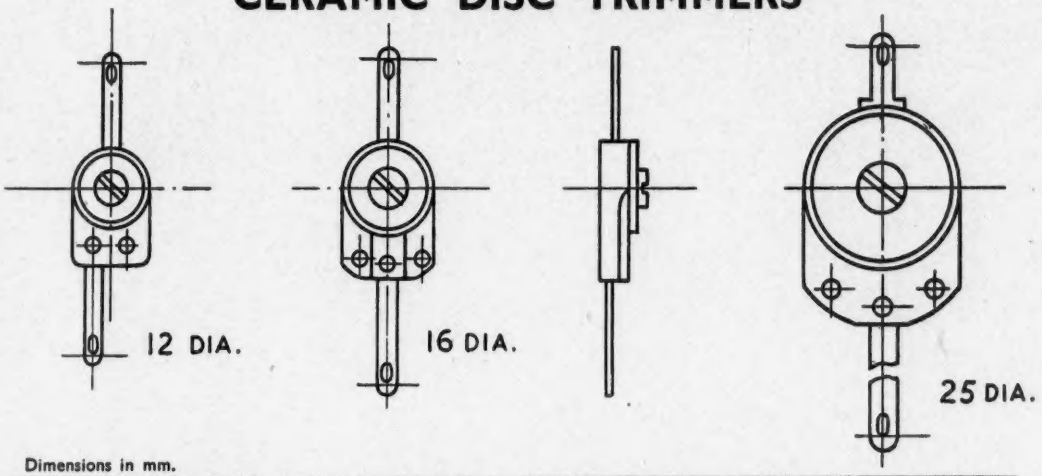

Dimensions in mm.

Dia. of Rotor	Name	Material of Rotor	Capacitance Ranges		Power Factor with Max. Capacitance in 10-4	Temperature Co-efficient in 10-6 for Material of Rotor		Permittivity for Rotor	Working Voltage Testing Voltage
			Min. pF + 10%	Max. pF +50% −10%					
12	Triko 12	D6	2 —	6 —	less than 20	+120	+160	6	Working Voltage 250v. DC/175v. AC Testing Voltage 750v. DC
		D20	2 3	10 15	less than 20	+ 90	— 30	20	
		D50	4 6	20 30	less than 20	—350	—600	50	
		D90	4 6 10 15	20 30 45 45	less than 20	—650	—850	90	
16	Triko 16	D6	2 2	6 8	less than 20	+120	+160	6	Working Voltage : 350v. DC/250v. AC Testing Voltage : 1000v. DC
		D20	2 3	10 15	less than 20	+ 90	— 30	20	
		D50 D50	3 3 4 6	8 15 20 30	less than 20	—350	—600	50	
		D90	3 3 4 6 10 10 15	8 15 20 30 45 60 45	less than 20	—650	—850	90	
25	Triko 25	D6	2	10	less than 20	+120	+160	6	Working Voltage 350v. DC/250v. AC Testing Voltage 1000v. DC
		D20	4 6	20 30	less than 20	+ 90	— 30	20	
		D50	10 15	60 80	less than 20	—350	—600	50	
		D90	6 20 20	50 100 150	less than 20	—650	—850	90	
Example of Ordering : Trimmers in D20, 16 dia. 10/45 pF — Triko D20-16-10/45									

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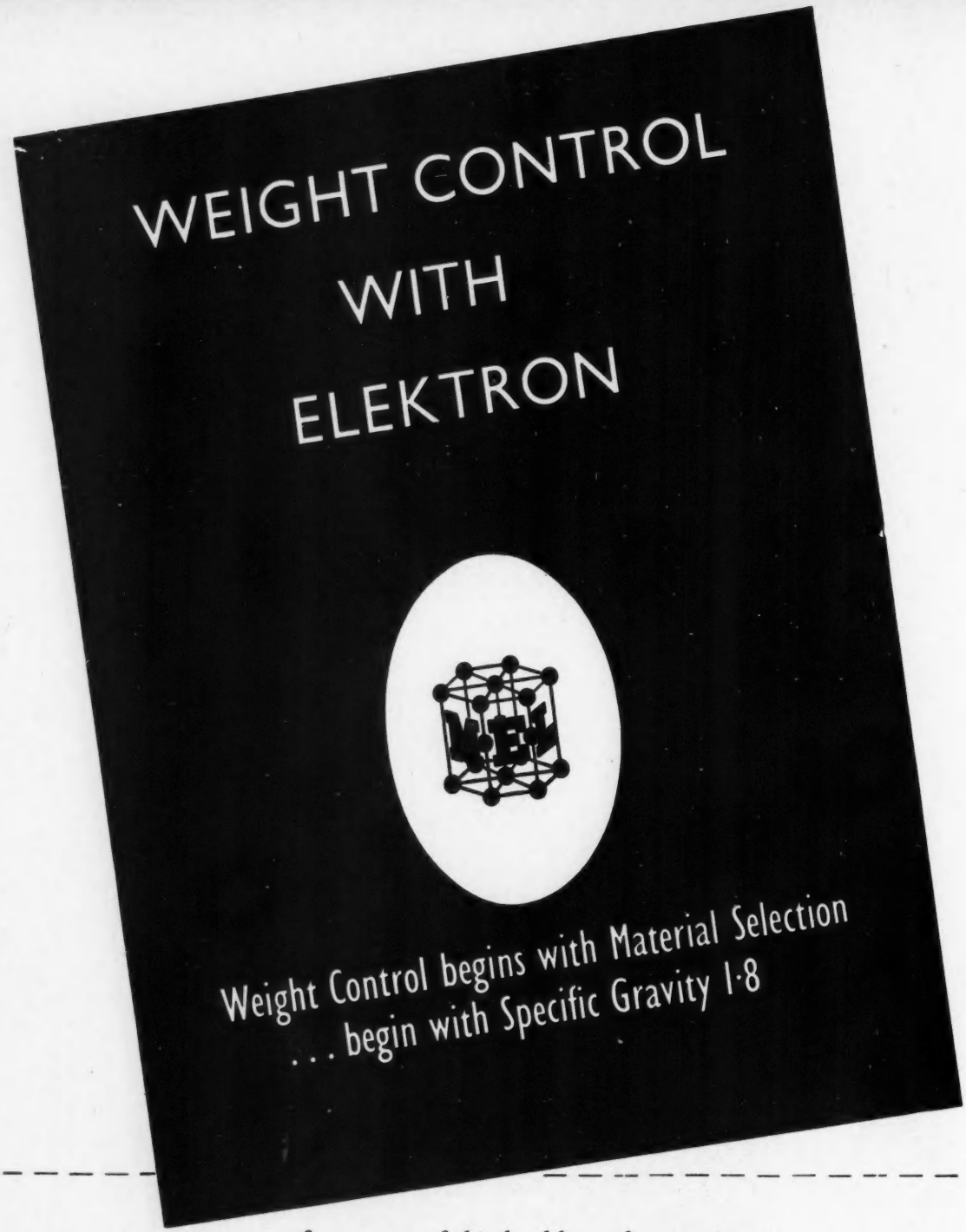

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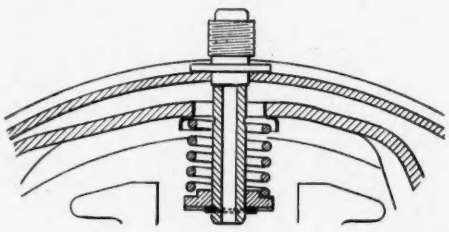

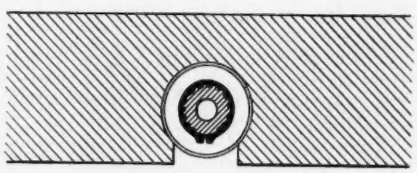

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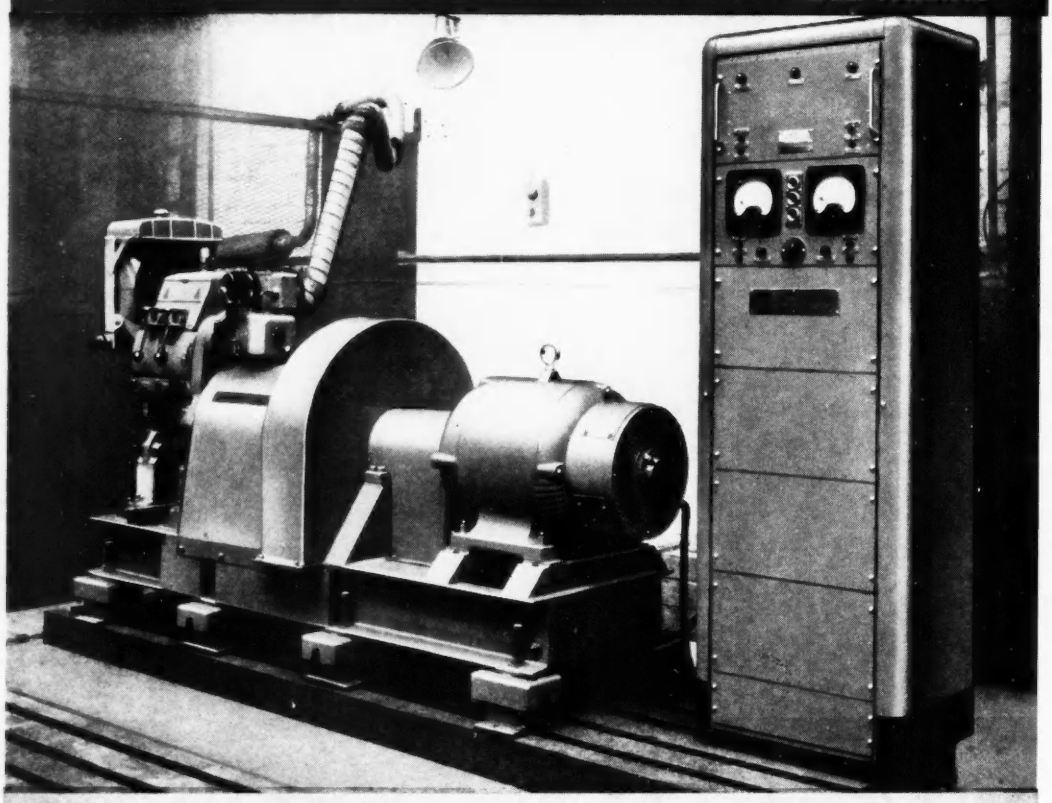

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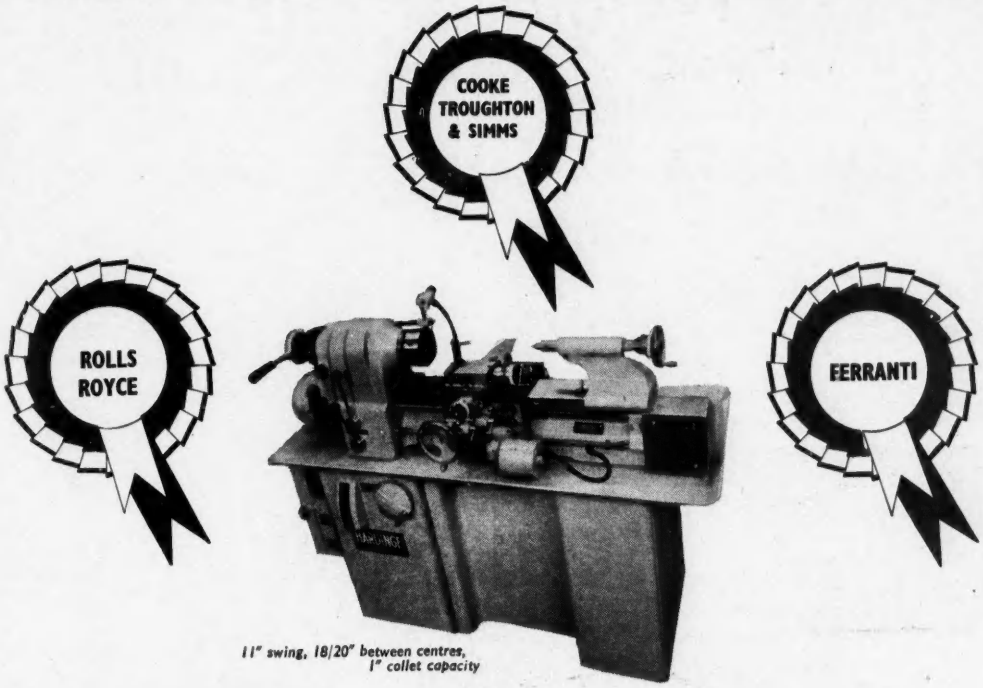

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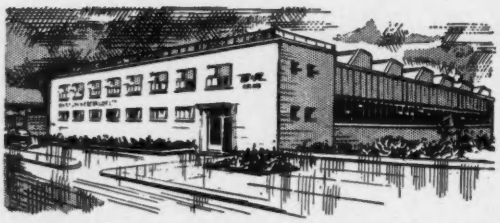

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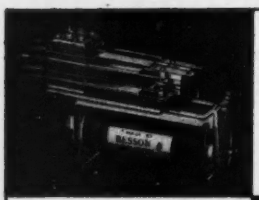

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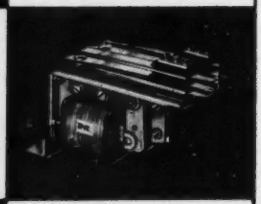

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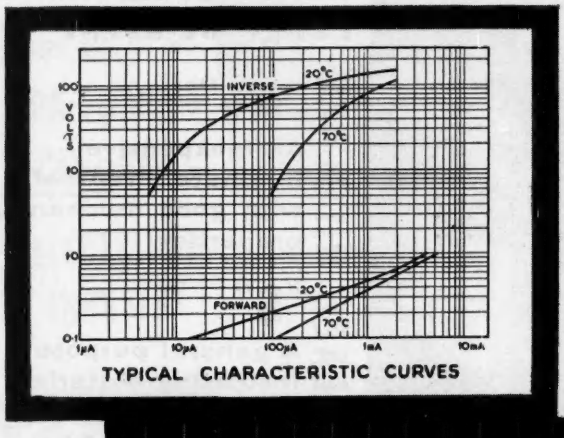

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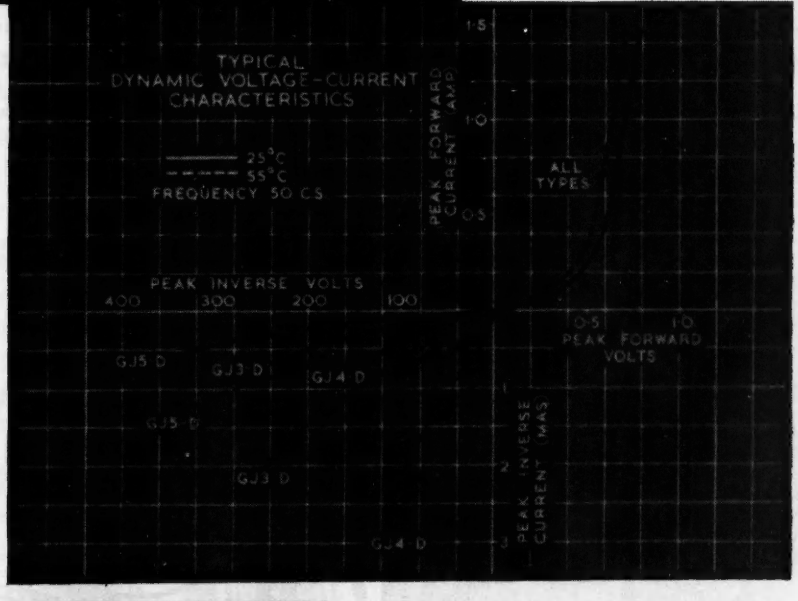

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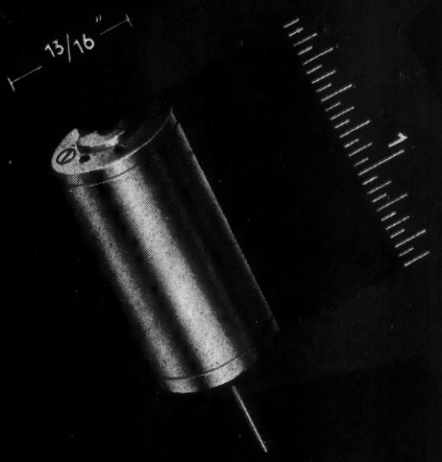

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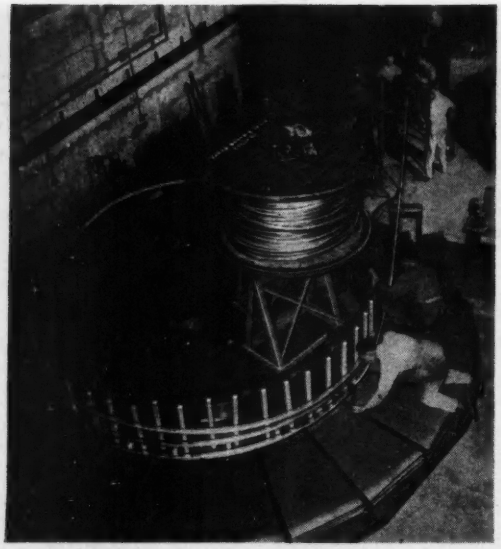
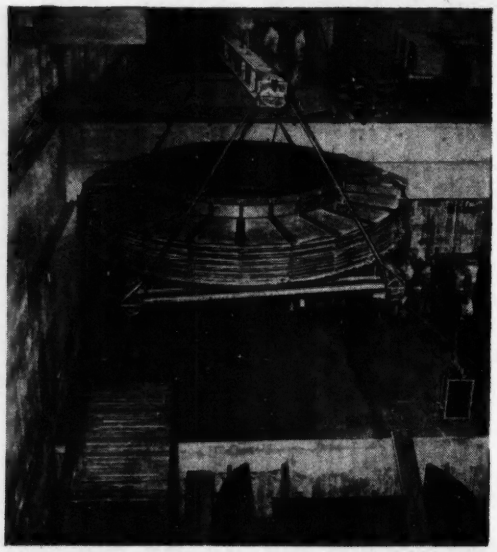
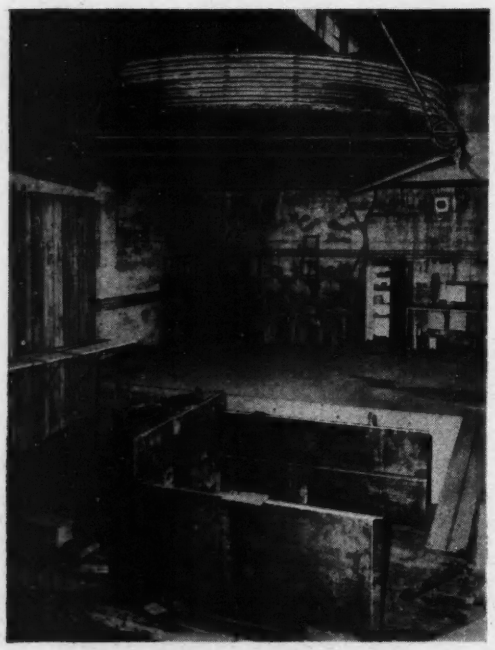


The aluminium being pulled through a tensioning device and wound on to the layer of pancakes that form the magnet energizing coils.



The completed job being lifted from the winding table. The partially built accelerator magnet is shown in the foreground.

CYCLOTRON WINDINGS



Another view of the completed winding.

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Photographs — reproduced by courtesy of the University — show the job in progress.

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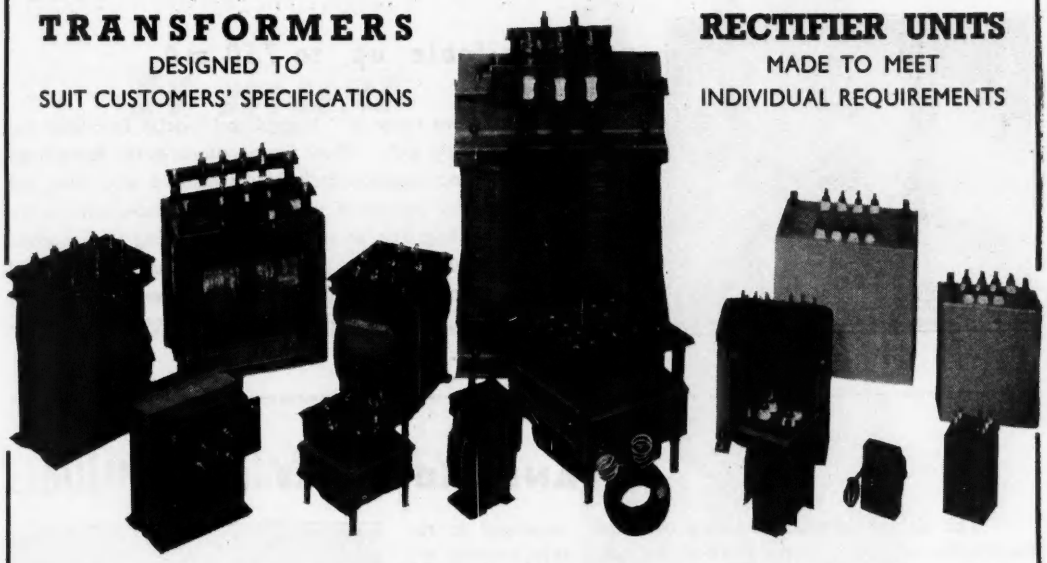

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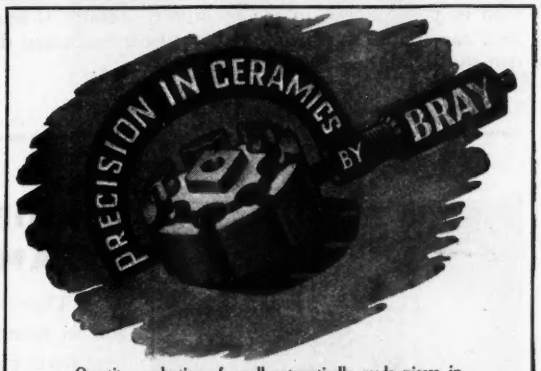

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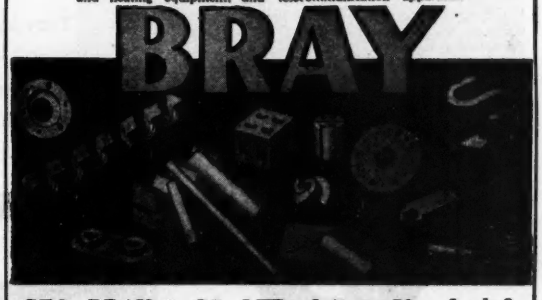

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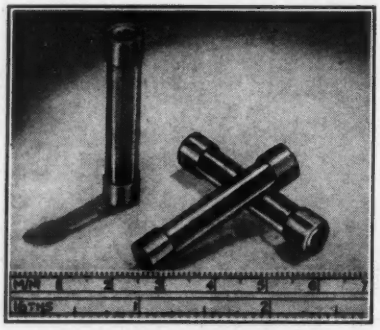

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Our well-known range of "Mag-Nickel" delay fuse-links are now available up to 750 mA. These fuses conform to the dimensions ($1\frac{1}{4}$" x $\frac{1}{4}$") and blowing requirements of the standard L.1055 fuse, but can withstand a surge current of 10/30 times their rated current for a period not exceeding 0.01 second, without affecting their normal length of life. Available in 250 mA (brown), 500 mA (yellow) and 750 mA (green) ratings, the colour coding conforming to B.S. 646(B).

"Mag-Nickel" Delay Fuse L.338

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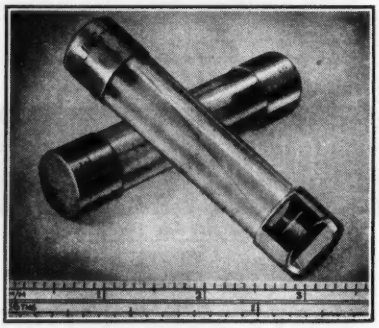

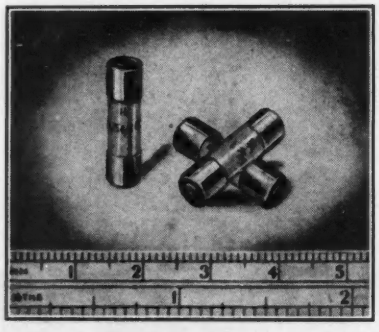

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These miniature fuse-links, measuring only $\frac{3}{8}$" x $\frac{3}{16}$", are available in ratings of .010, .015 and .025 A. They are the result of long development to enable such a fine element to be handled in production to give reliable service in the three ratings mentioned.

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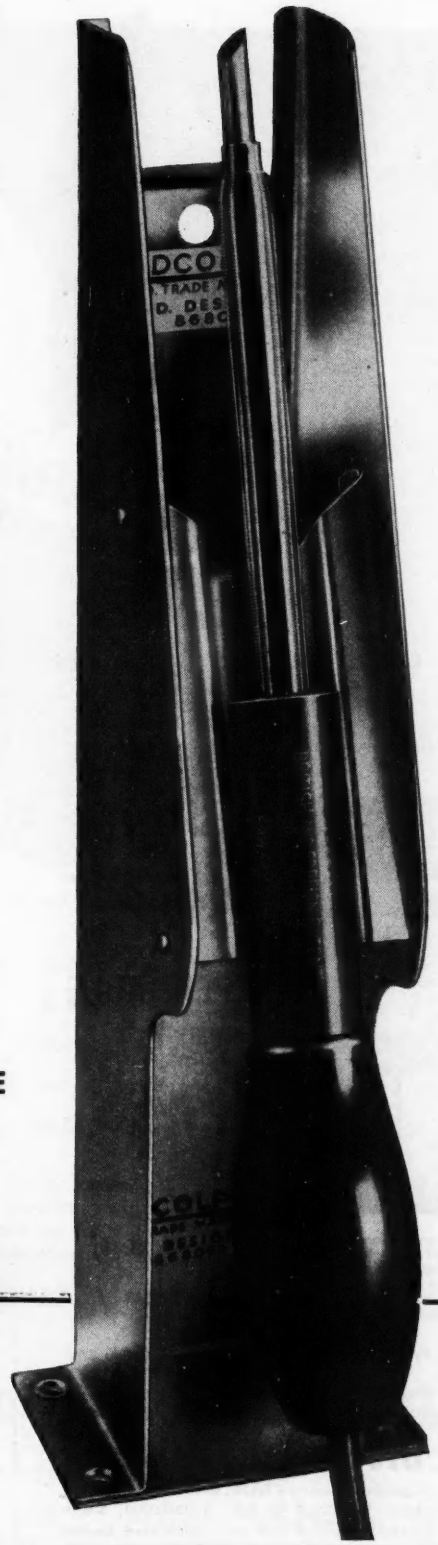

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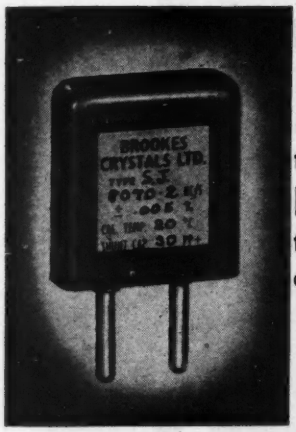

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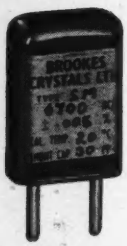

● *Illustrated above is a Type SJ Crystal Unit from a range covering 3-20 mc/s and on the right is a Type SM Crystal Unit from a range covering 3-20 mc/s.*

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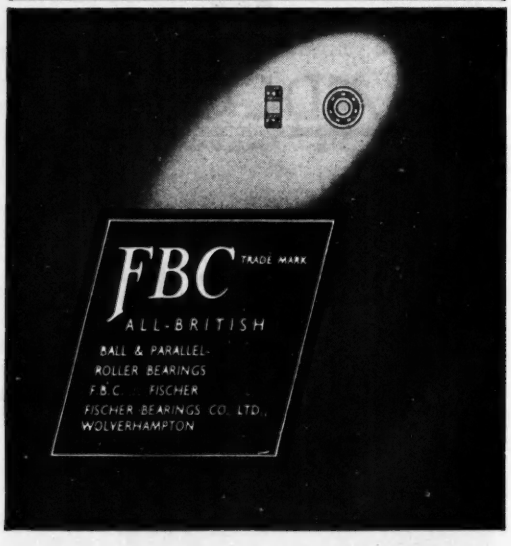

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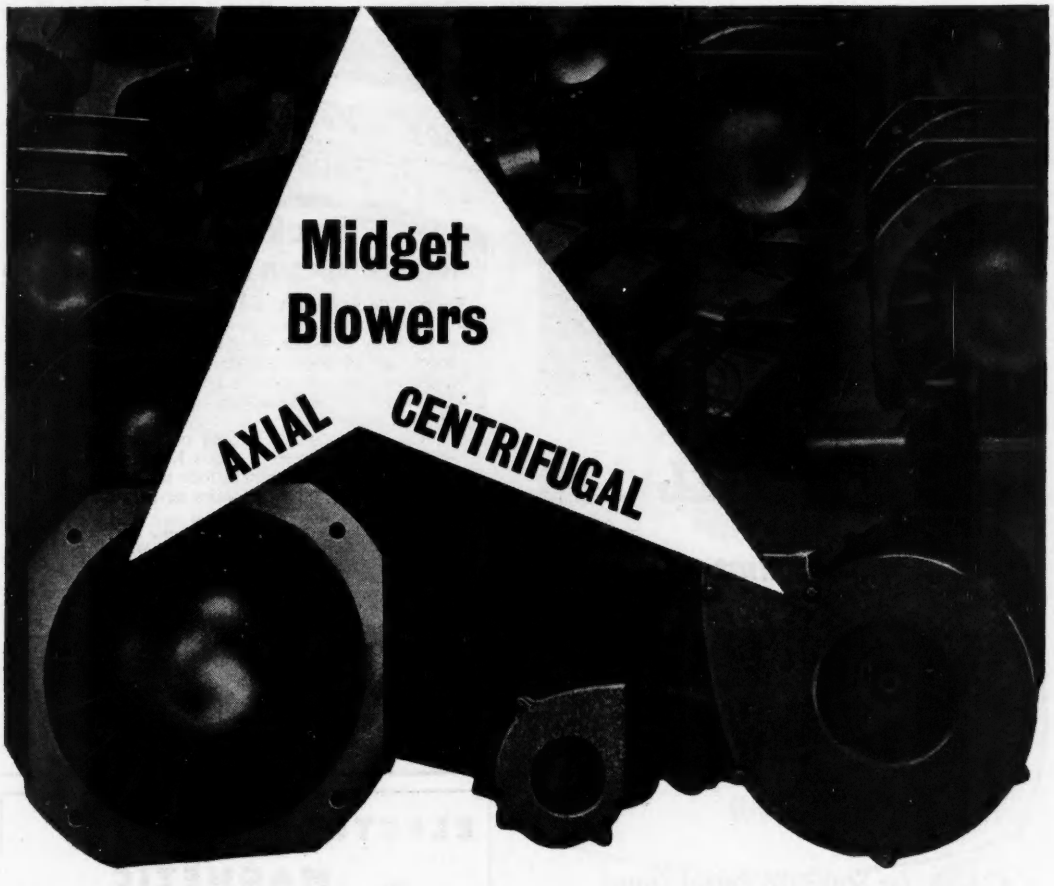

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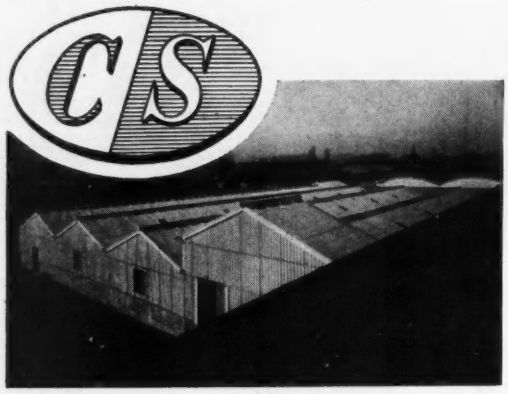

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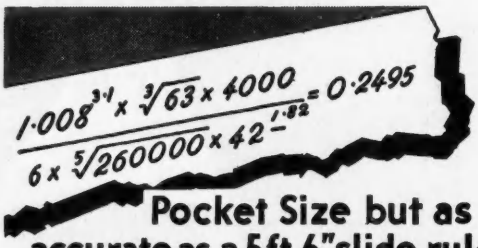

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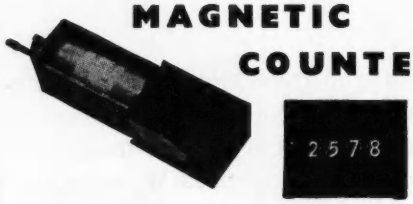

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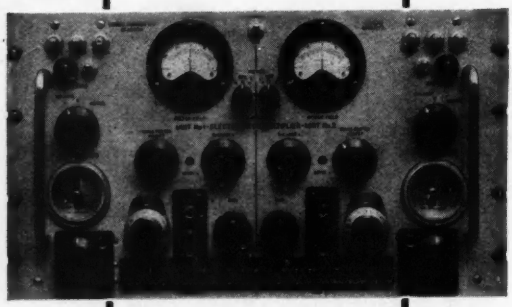

$$y = f_1(x)\left\{f_2(s) + \ldots + f_6(w)\right\} + f_7(z)\left\{f_8(l) + \ldots + f_{12}(p)\right\}$$

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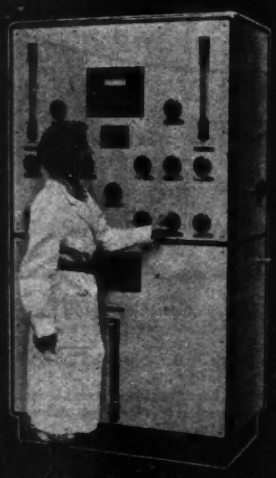

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(Further information on request)

	Data	Model 501	Model 502	Model 503	Model 504	Model 505
MAIN +VE Stabilizer	Output	200-500V 250mA	200-500V 250mA	0-500V 250mA	0-500V 250mA	0-500V 150mA
	Number of Ranges	2	2	4	4	1
	Voltage Stabilization	±0.02%	±0.002%	±0.1%	±0.002%	±0.1%
	Effective Output Resistance (max.)	0.2 Ω	0.02 Ω	0.5 Ω	0.02 Ω	0.5 Ω
	Output Ripple (rms. max.)	2mV	1mV	3mV	1mV	3mV
—VE Supply Stabilizer	Outputs	—	—	250V 25mA 0—250V 1mA	250V 25mA 0—250V 1mA	250V 25mA 0—250V 1mA
	Voltage Stabilization	—	—	±0.05%	±0.002%	±0.05%
	Output Resistance (max.)	—	—	1 Ω	0.01 Ω	1 Ω
	Output Ripple (rms. max.)	—	—	2mV	1mV	2mV
Unstabilized +VE H.T. Supply 250mA max.		470V 630V	470V 630V	320V 470V 630V	320V 470V 630V	630V
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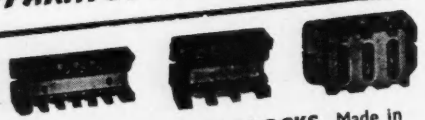

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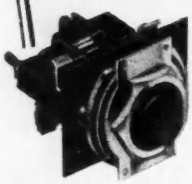

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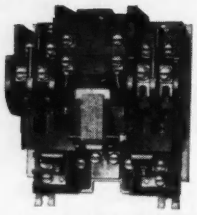

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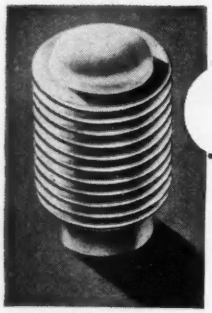

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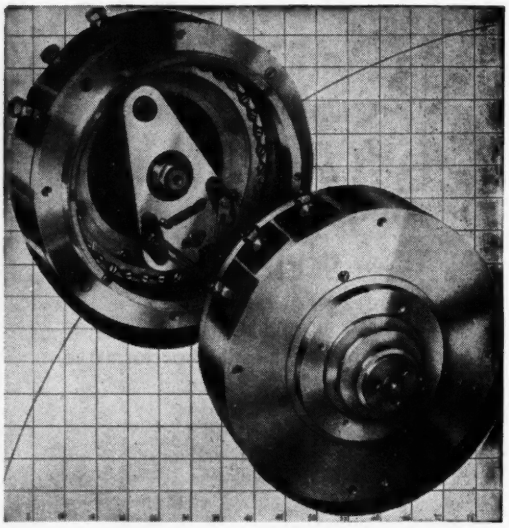

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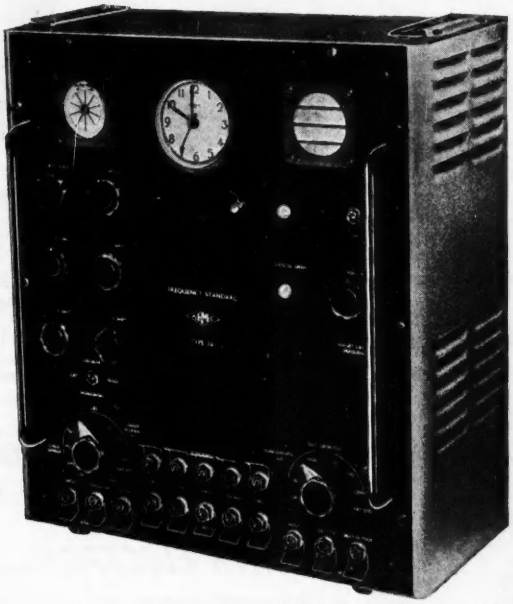

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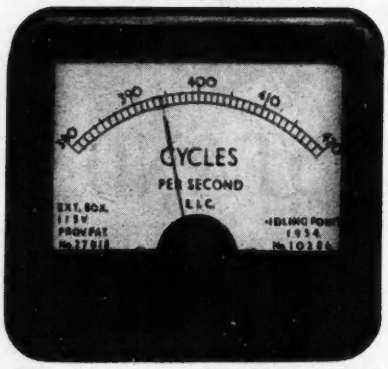

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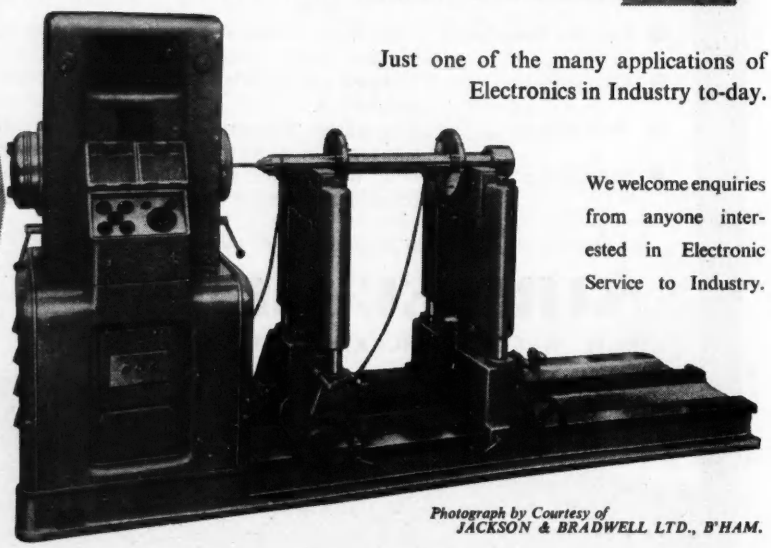

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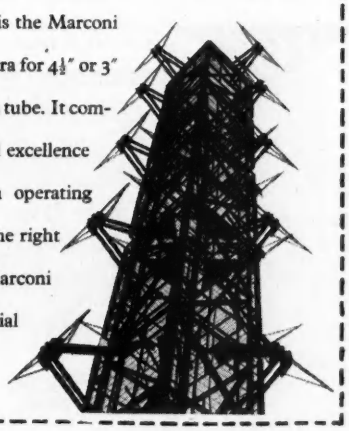

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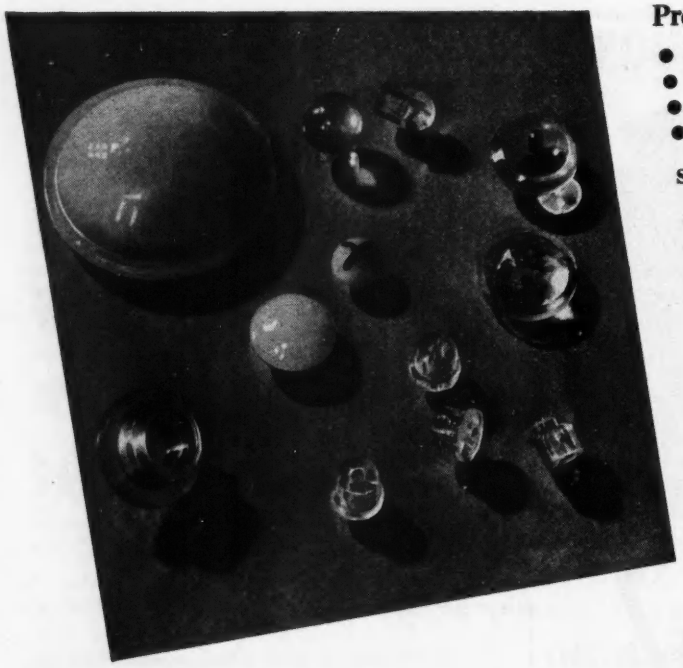

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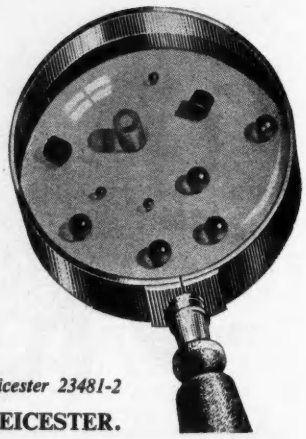

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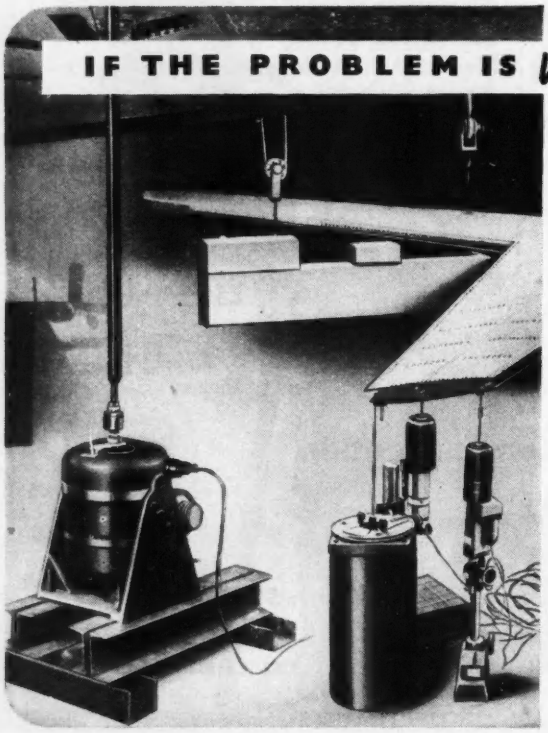

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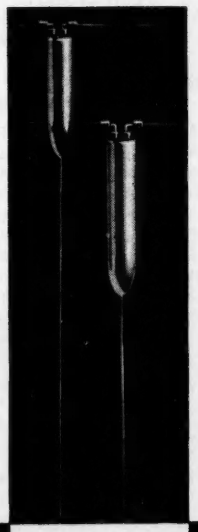

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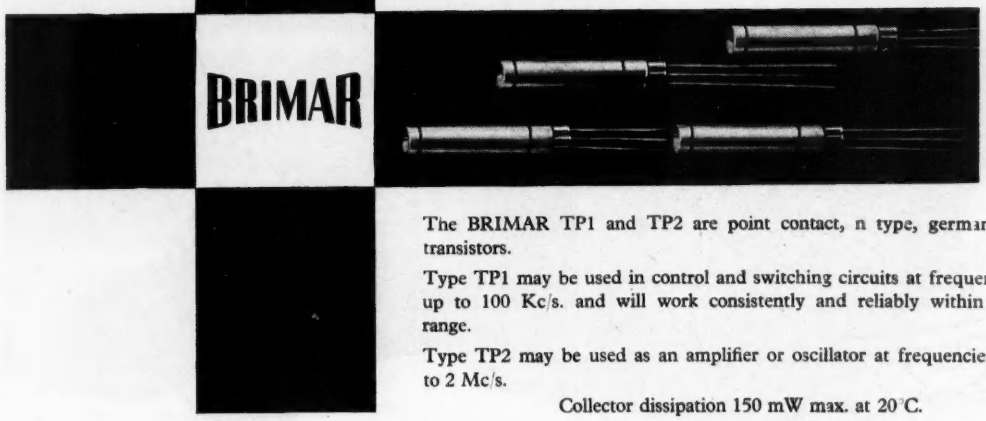

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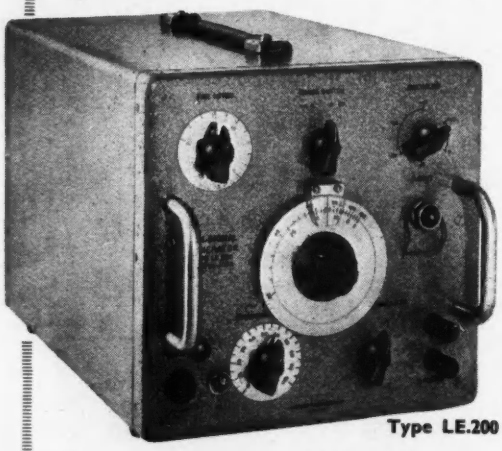

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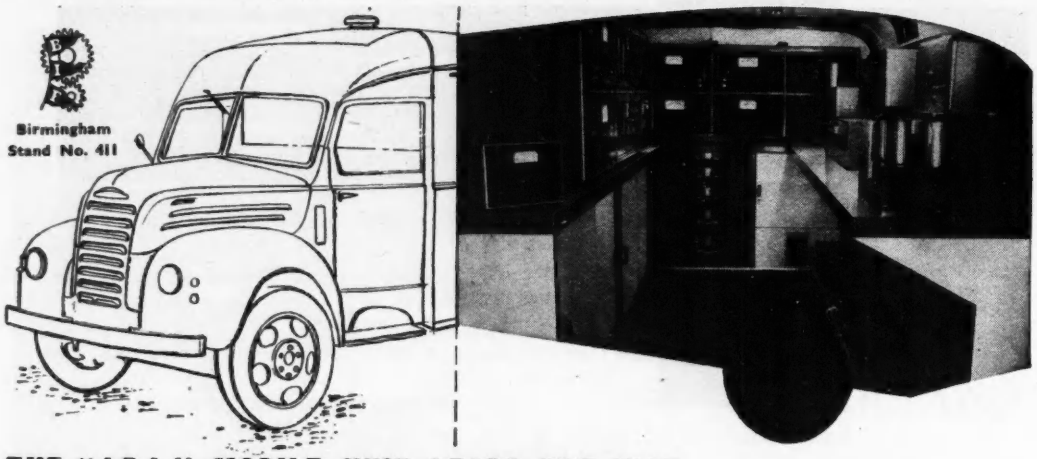

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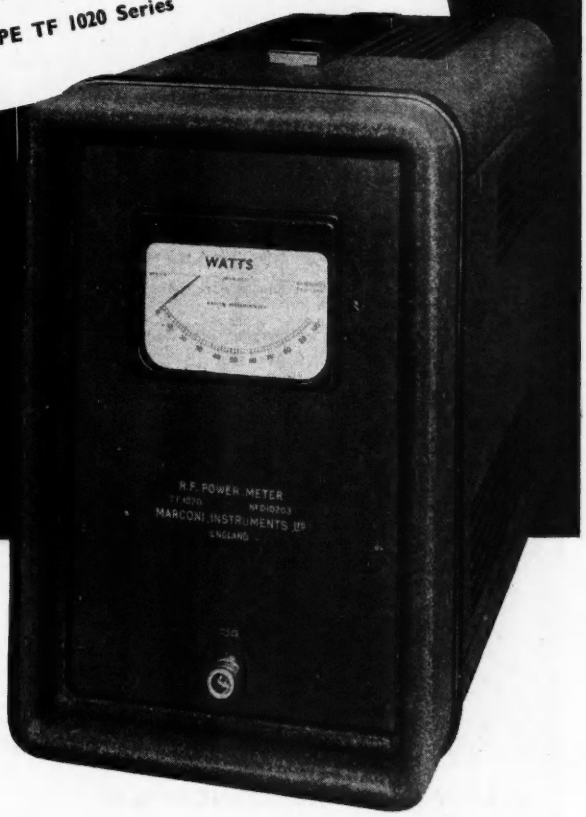

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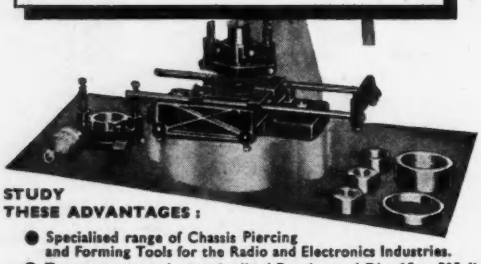

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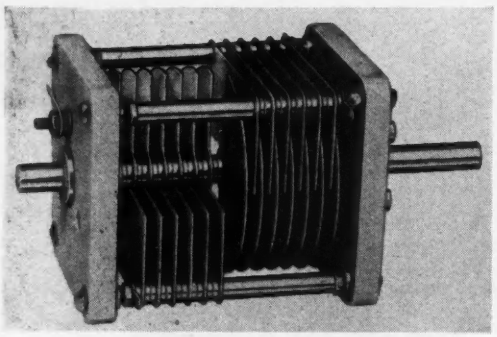

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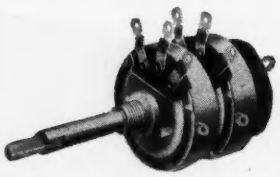

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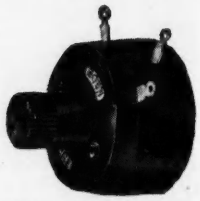

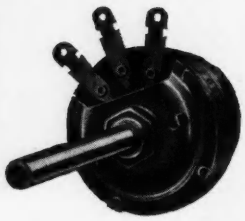

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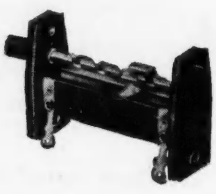

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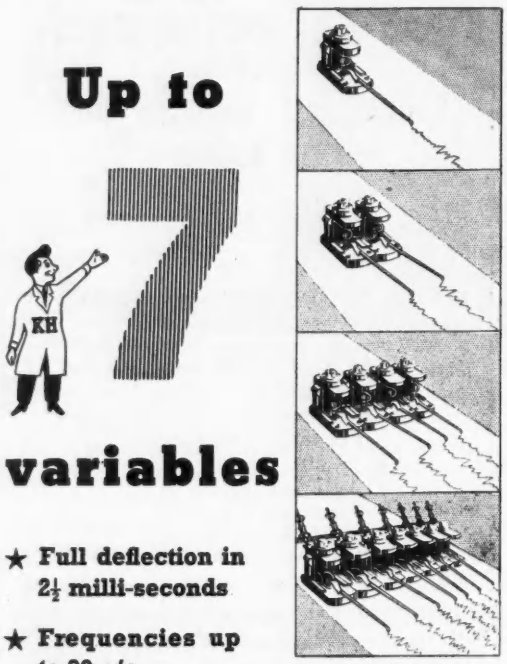

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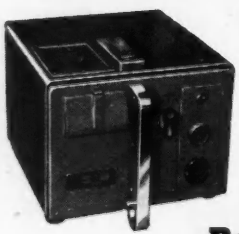

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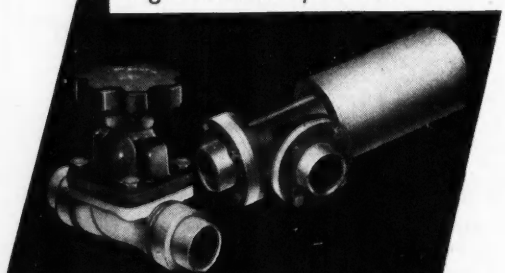

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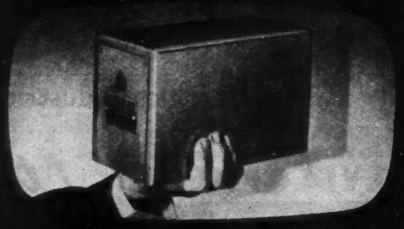

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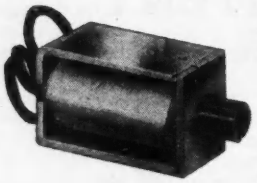

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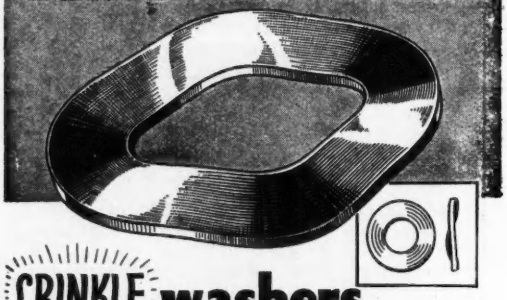

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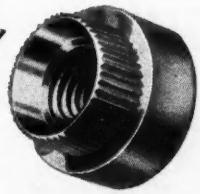

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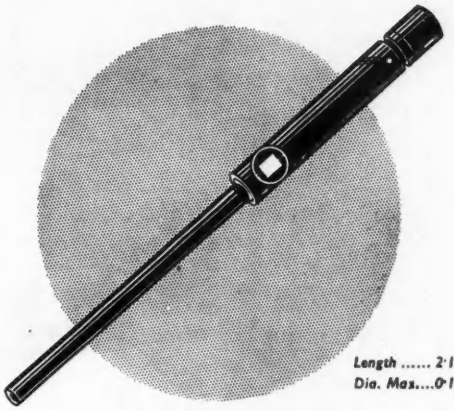

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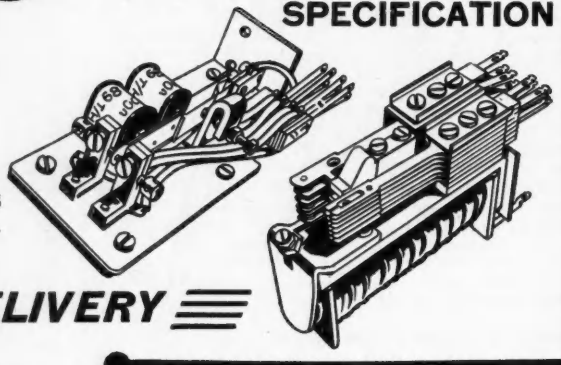

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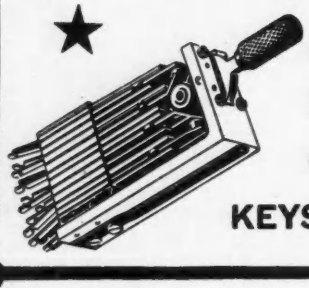

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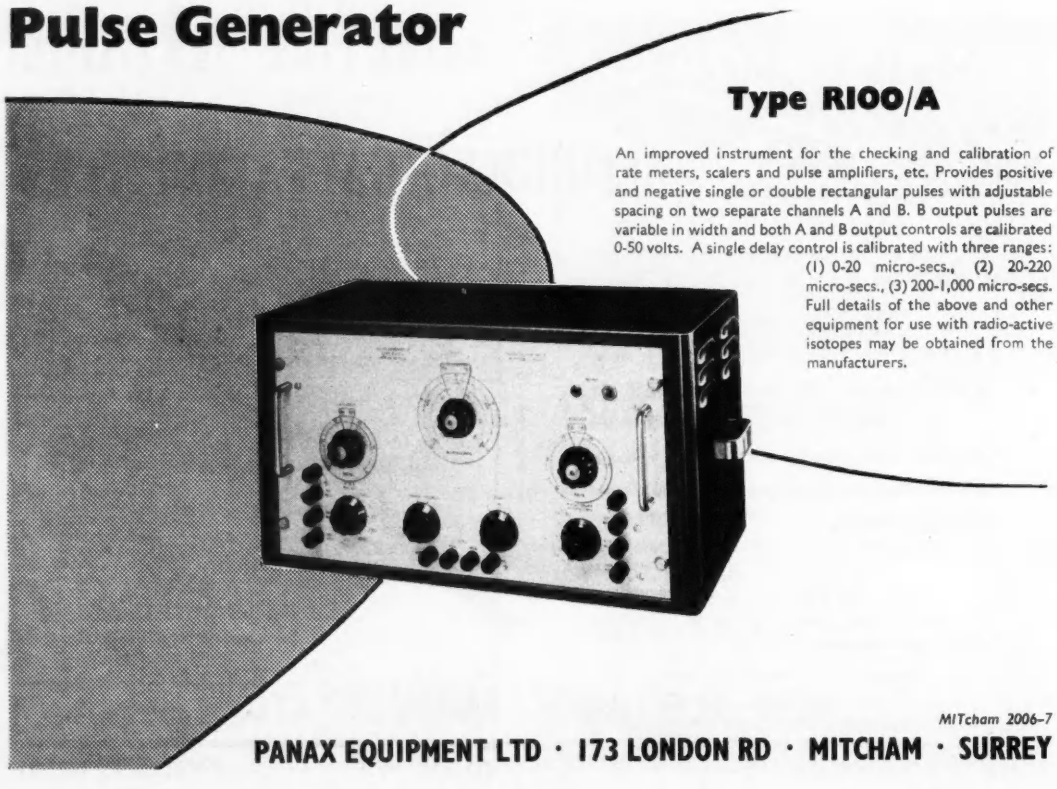

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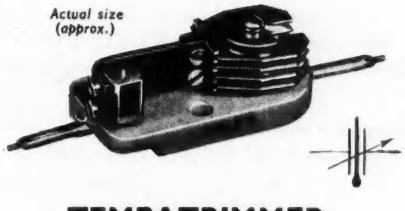

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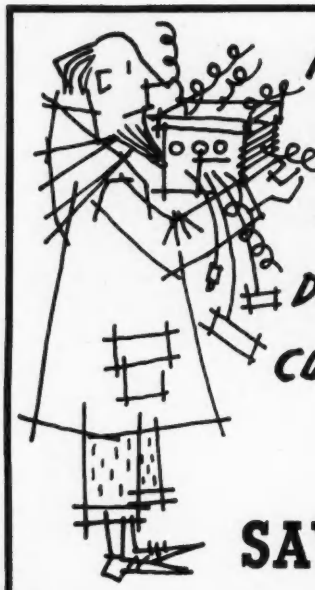

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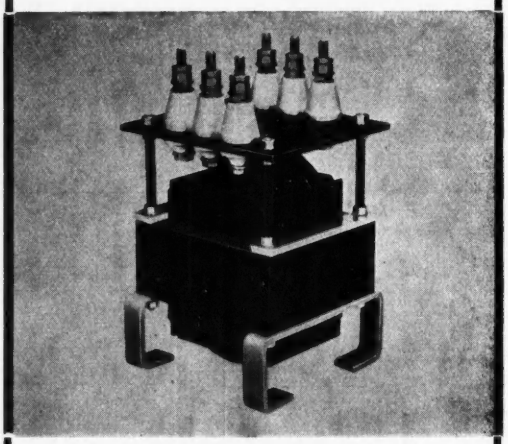

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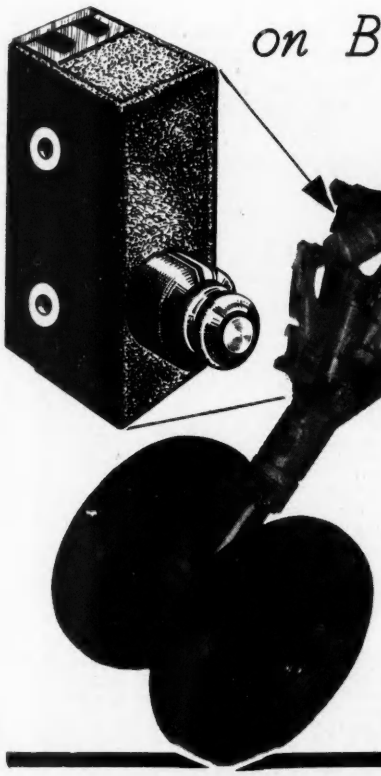

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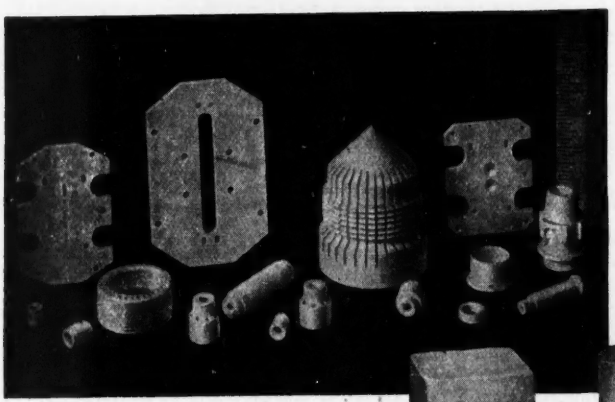

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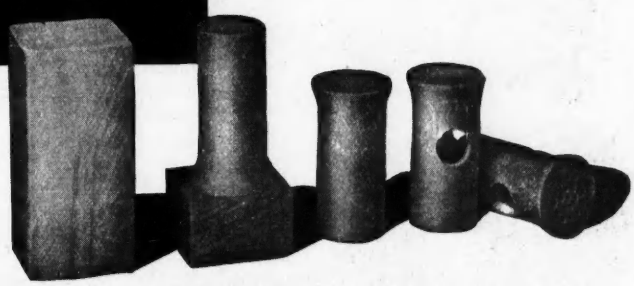

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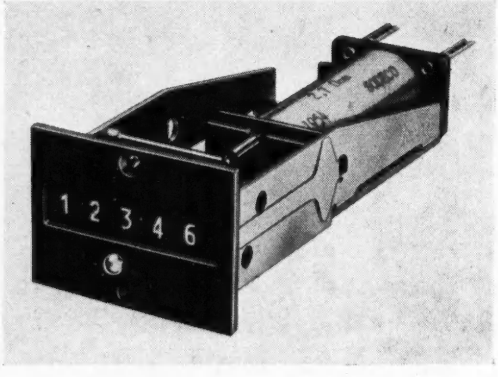

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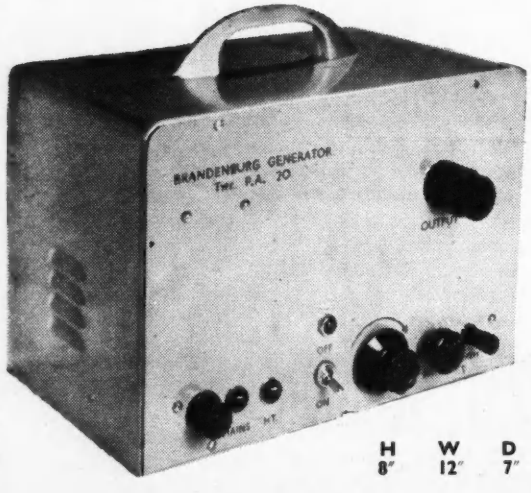

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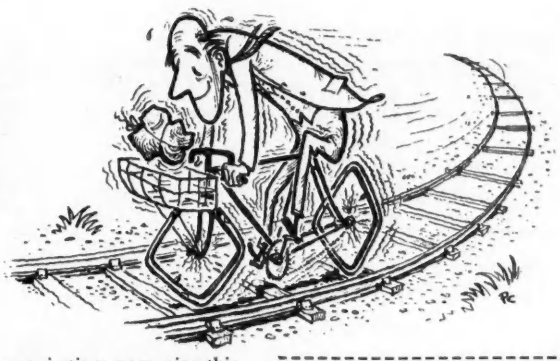

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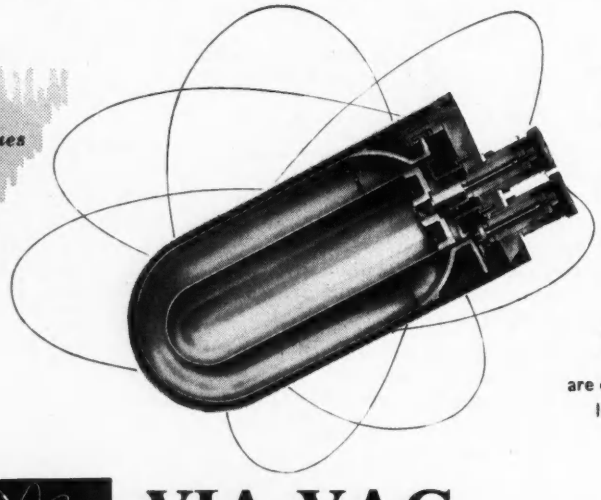

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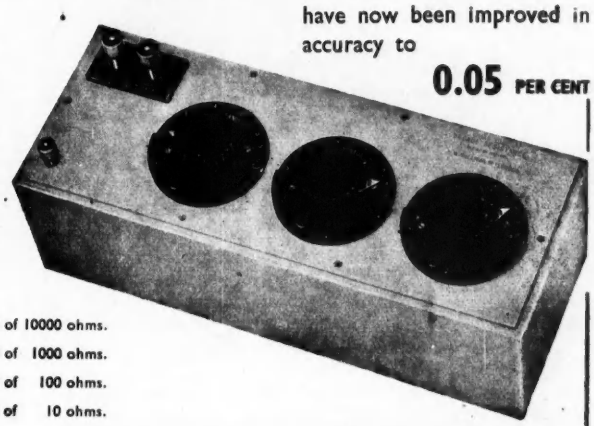

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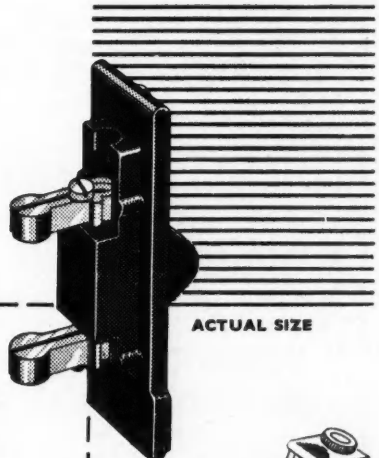

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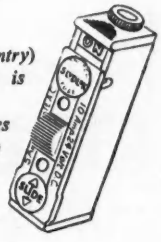

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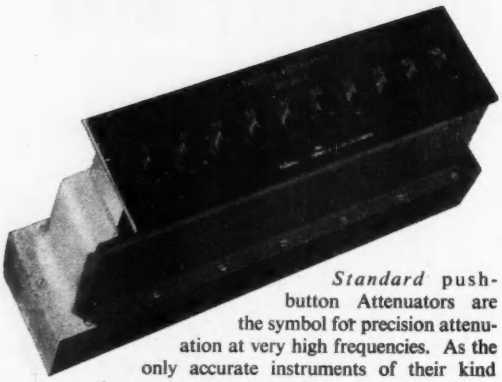

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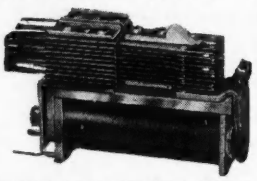

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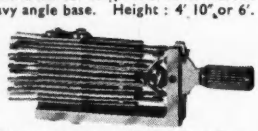

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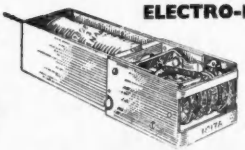

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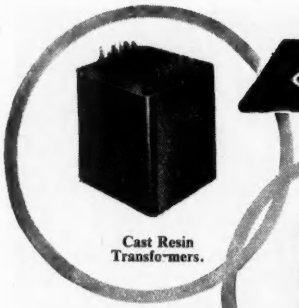

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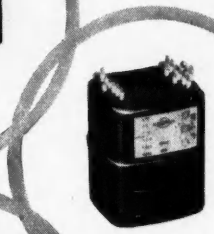

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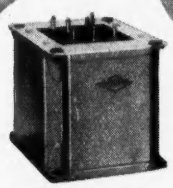

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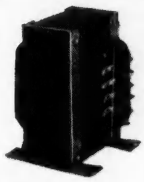

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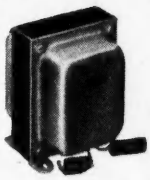

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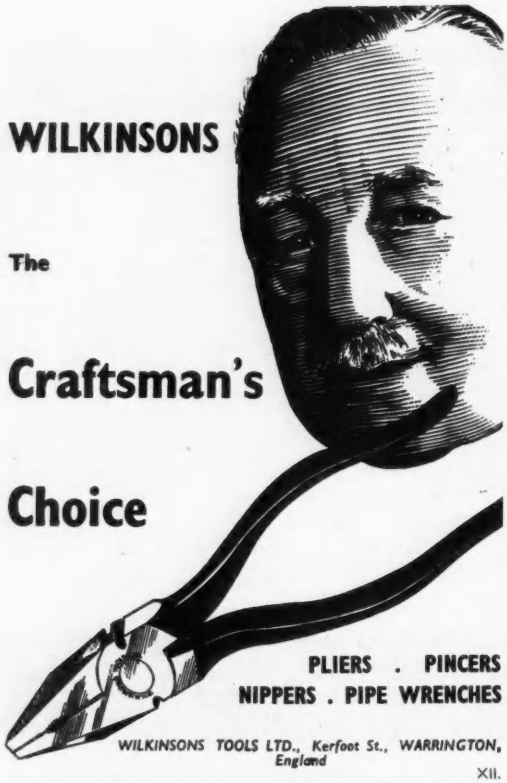

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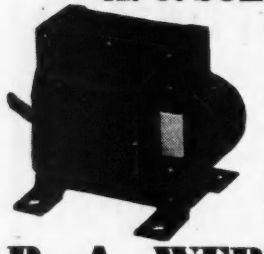

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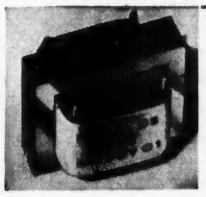

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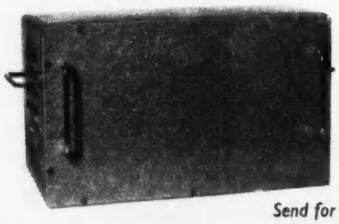

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INDEX TO ADVERTISERS

A

Acheson Colloids Ltd. 87
Adcola Products Ltd. 101
Advance Components Ltd. 53
Aero Research Ltd. 66
Air Control Installation Ltd. 103
Airmec Ltd. 109
A. K. Fans Ltd. 72
Alloy Wire Co. Ltd. 139
All-Power Transformers Ltd. 107
Ashton Ltd., N. C. 72
Atkins, Robertson & Whiteford Ltd. 74
Automatic Coil Winder & Equipment Co. Ltd., The 105
Aveley Electric Ltd., 73
Avis & Baggs Ltd. 139

B

Barr & Stroud Ltd. 76
Bell & Croyden, John 139
Belling & Lee Ltd. 100
Birmingham Specialities Ltd. 139
Blickvac Ltd. 74
Booth & Co. Ltd., James 98
Bray & Co. Ltd., George 99
Brayhead Springs Ltd. 76
British Driver-Harris Ltd. 99
British Electric Resistance Co. Ltd. 80
British Instrument Industries Exhibition 78
British Insulated Callender's Cables Ltd. 61
British Plastics Developments Ltd. 102
British Thomson-Houston Co. Ltd. 95
Brooke's Crystals Ltd. 102
Broxlea Products Ltd. 19
Bruel & Kjaer 141
Bullers Ltd. 86
Burgess Products Co. Ltd. 84

C

Canning Ltd., W. 106
Carbic Ltd. 104
Cathodeon Ltd. 79
Cementation (Muffelite) Ltd. 78
Chapman & Hall 233
Chamberlain & Willows 139
Chilton Steel Ltd. 104
Cinema-Television Ltd. 82
Clarke & Co. (Manchester) Ltd., H. 80
Colborne Engineering Co. Ltd., The 106
Cole Ltd., E. K. 6
Colvern Ltd. 108
Cooper & Co. (Birmingham) Ltd. 102
Cossor Ltd., A. C. 51
Cressall Manufacturing Co. Ltd. 102

D

Daly (Condensers) Ltd. 81
Darwins Ltd. 142
Davis (Relays) Ltd., Jack 104
De Havilland Aircraft Co. Ltd., The 110
Dobbie McInnes Ltd. 106
Donovan Electrical Co. Ltd. 108
Dowding & Doll Ltd. 49
Drayton Regulator & Instrument Co. Ltd. 108
Dubilier Condenser Co. (1925) Ltd. 77

E

Edison Swan Electric Co. Ltd. Cover ii, 33 and 71
Egen Electric Ltd. 116
Elco Plastics Ltd. 139
Electrical Instrument Co. (Hillington) Ltd. 110
Electric Construction Co. Ltd., The 92
Electrochemical Laboratories 121
Electronic Engineering Monographs 131 and 233
Electrothermal Engineering Ltd. 81
Elliott Bros. (London) Ltd. 75
E.M.I. Factories Ltd. 47
E.M.I. Institutes Ltd. 121
E.M.I. Sales & Service Ltd. 60
English Electric Co. Ltd., The 31 and 59
English Glass Co. Ltd. 112
Enthoven & Sons Ltd., J. H. 43
Ericsson Telephones Ltd. 54
Evans Electronic Developments Ltd. 110
Evershed & Vignoles Ltd. 41

F

Ferranti Ltd. 57
Fischer Bearings Co. Ltd. 102
Foster Transformers & Switchgear Ltd. 39
Fox Ltd., P. X. 58

G

Gardner's Radio Ltd. 76
Garrard Engineering & Manufacturing Co. Ltd., The 35
General Electric Co. Ltd., The 29
General Engineering Co. (Radcliffe) Ltd. 55
Goodman's Industries Ltd. 112
Gresham Transformers Ltd. 56

H

Haddon Transformers Ltd. 73
Hardinge Machine Tools Ltd. 93
Hassett & Harper Ltd. 52
Hatfield Instruments Ltd. 114
Henley's Telegraph Works Co. Ltd., W. T. 121
Hill Ltd., C. & L. 50
Hilton Electric Co. Ltd. 81
Hunt Ltd., A. H. 48
Hunton Ltd. 116

I

Imperial Chemical Industries Ltd. 62
Imperial Chemical Industries Ltd., Plastics Division 27
International Engineering Concessionaires Ltd. 121
Isotope Developments Ltd. 114

J

Jackson Bros. 116
Johnson, Matthey & Co. Ltd. 7

(continued on next page)

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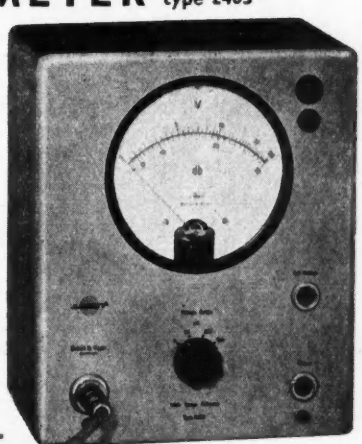

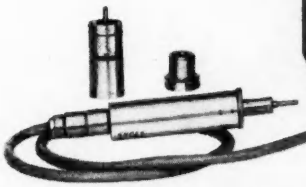

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INDEX TO ADVERTISERS (*continued from previous page*)

K

Kelvin & Hughes Ltd. 120
Kempe's Engineers Year Book 232
Kendall & Mousley Ltd. 121
Keyswitch Co., The 124

L

Labgear (Cambridge) Ltd. 120
Langham-Thompson Ltd., J. 46
Lewis & Co. Ltd., H. K. 122
Lewis Spring Co. Ltd. 3
London Electric Wire Co. & Smiths Ltd. & Vactite Wire Co. Ltd. 118
Lyons Ltd., Claude 122

M

Magnesium Elektron Ltd. 90
Magnetic Devices Ltd. 42
Marconi Instruments Ltd. 115 and 119
Marconi's Wireless Telegraph Co. Ltd. 23 and 111
Muirhead & Co. Ltd. 44
Mullard Ltd. 45 and 70
Multicore Solders Ltd. Cover iv
Murex Ltd. 118
Murphy Radio Ltd. 15

N

National Plastics (Sales) Ltd. 40
Neill & Co. (Sheffield) Ltd., James 125
New Electronics Products Ltd. 123
N.G.N. Electrical Ltd. 120

O

Oxley Developments Ltd. 125

P

Painton & Co. Ltd. Cover i
Panax Ltd. 124
Pelapone Engines Ltd. 34
Pell Control Ltd., Oliver 94
Philips Electrical Ltd. 83
Phillips Control (G.B.) Ltd. 122
Planer Ltd., G. V. 125
Plasticable Ltd. 122
Plessey Co. Ltd., The 63, 85 and 88
Power Controls Ltd. 32
Power Jacks Ltd. 85
Powis & Sons Ltd., David 122
Precision Rubbers Ltd. 3
Precision Screw Co. Ltd. 123
Pressparn Ltd. 122
Prestware Ltd. 36
Protona G.m.b.H. 97
Pye Ltd., W. G. 38

R

Radiant Metal Finishing Co. Ltd. 127
Radio Resistor Co. Ltd. 30
Radiospares Ltd. 140
Ragosine Oil Co. Ltd. 94
Randall & Son Ltd., James H. 140
Ratcliffe (Rochdale) Ltd., F. S. 69
Record Electrical Co. Ltd., The 28
Redifon Ltd. 83
Rivlin Instruments Ltd. 126
Roe & Co. Ltd., A. V. 85 and 140
Rola-Celestion Ltd. 126
Royce Electric Furnaces Ltd. 20
Rubber Improvement Ltd. 96

S

Salford Electrical Instruments Ltd. 127
Salter & Co. Ltd., George 37 and 91
Sandwell Casting Co. Ltd. 97
Sankey & Sons Ltd., Joseph 96
Saunders-Roe Ltd. 128
Savage Ltd., W. Bryan 133
Savage Transformers Ltd. 128
Selig Electro-Magnetics Ltd. 138
Servo & Electronic Sales Ltd. 140
Servomex Controls Ltd. 16 and 17
Sheffield Smelting Co. Ltd. 129
Short Bros. & Harland Ltd. 22
Solartron Electronic Group Ltd. Cover iii
Southern Instruments Ltd. 26
Spear Engineering Co. Ltd. 140
Specto Ltd. 130
Standard Telephones & Cables Ltd. 25, 113 and 136
Steatite Insulations Ltd. 89
Steatite & Porcelain Products Ltd. 24
Stonebridge Electrical Co. Ltd., The 132
Sugg Ltd., William 129
Sullivan Ltd., H. W. 135
Superflexit Ltd. 18
Sutton Coldfield Electrical Engineers 140
Symons Ltd., H. D. 134

T

Teleonics Ltd. 132
Telephone Manufacturing Co. Ltd. 130
Thomas (Richard) & Baldwins Ltd. 68
Transradio Ltd. 131
Trumeter Co. Ltd. 97
Tucker Eyelet Co. Ltd., George 133
Twentieth Century Electronics Ltd. 67

U

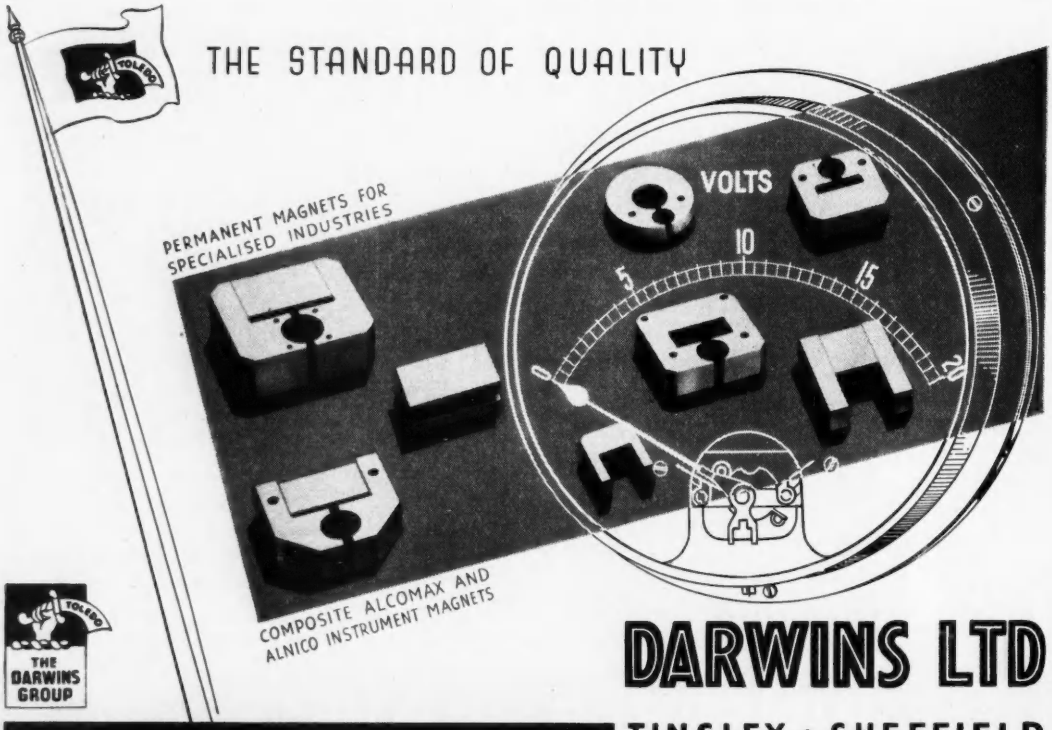
Universal Pulp Containers Ltd. 117

V

Vactric Ltd. 21
Vacuum Industrial Applications Ltd. 134
Veeder-Root Ltd. 136
Venner Accumulators Ltd. 138

W

Walters & Son Ltd., Austin 99
War Office, The 137
Webber Ltd., R. A. 138
Welwyn Electrical Laboratories Ltd. 64
Westool Ltd. 65
Wilcox & Co. Ltd., Edward 135
Wilkinson, L. 136
Wilkinson's Tools Ltd. 138
Wilmot (Electronics) Ltd. 137
Woden Transformers Co. Ltd. 137



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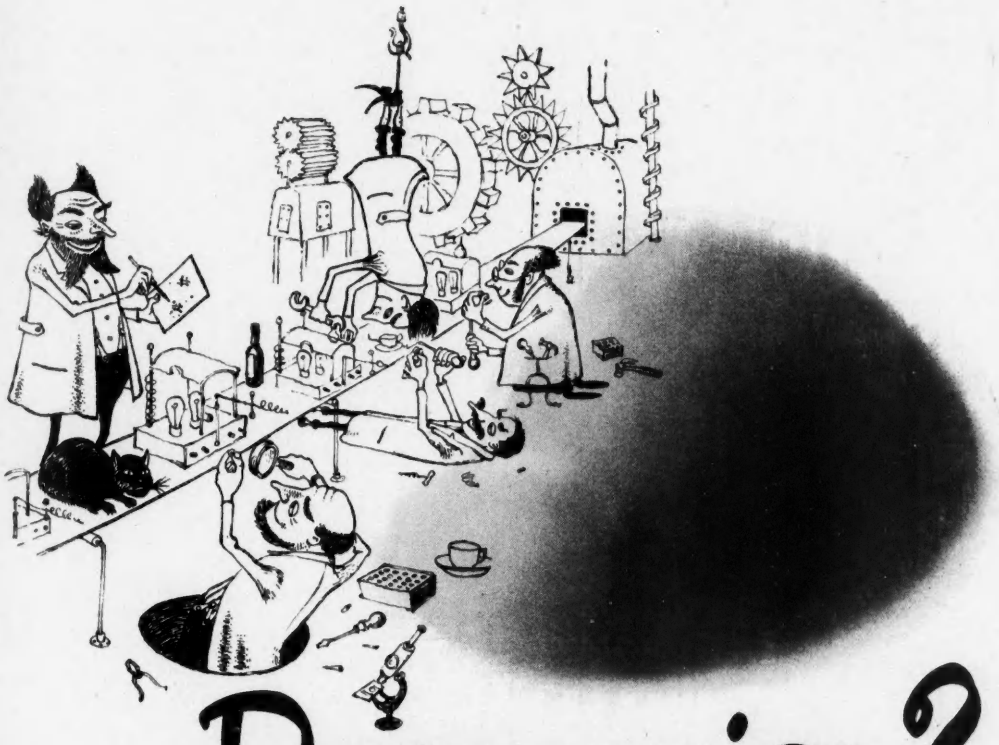

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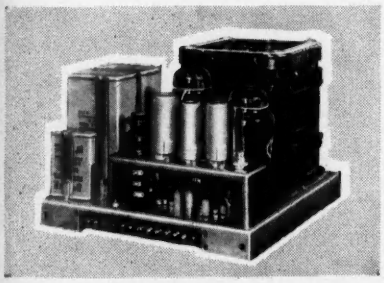

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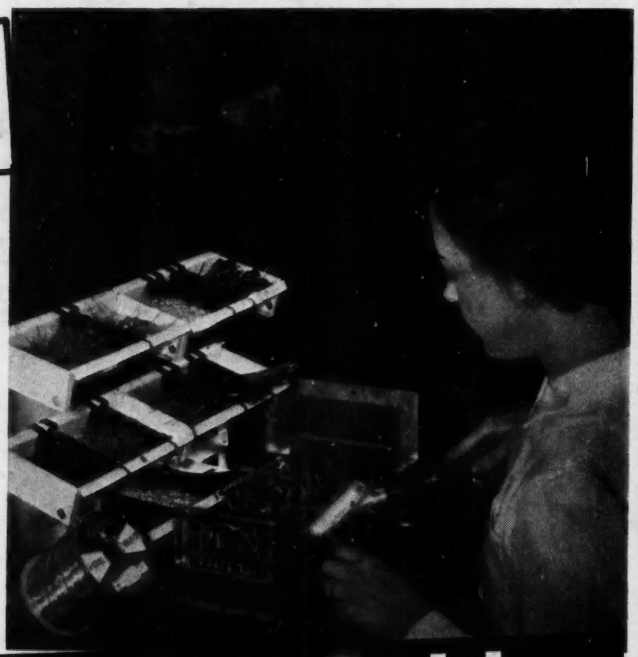

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